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UTAH SCIENCE

MARCH 1967

Volume 28

Number 1

AGRICULTURAL EXPERIMENT STATION • UTAH STATE UNIVERSITY • LOGAN





Practically no additional water can be developed in Utah by direct diversion of natural stream flow. The natural late flow of Utah's streams was appropriated many years ago.

Developing new water supplies usually involves drilling wells or damming the streams to hold back the high spring runoff.

Better utilization of existing water supplies is one way of immediately attacking this scarcity of water in Utah. This is an area of vital concern to the Utah farmer or rancher.

The lining of irrigation ditches and canals with cement, asphalt, rubber, or plastic film can save millions of gallons annually. Putting in small reservoirs or ponds to catch run-off can save thousands of acre-feet which run to waste each year.

Using sprinkling systems to apply water instead of flooding can stretch agricultural water much further. Preventing the growth of phreatophytic vegetation along ditches and canals saves even more.

If all these methods were utilized where they are economically justifiable, it would greatly improve the present agricultural water situation in Utah.

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UTAH SCIENCE

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The Utah Center For Water Resources Research

HOWARD B. PETERSON

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Our national appetite for water is voracious. The demands of cities, towns, industries, agriculturists, recreationists, and other users for clean water will probably double before the turn of the century. But even as the demands multiply, water quality deteriorates. Many streams are already putrescent and some rivers are little more than open sewers.

No one area of the country has a corner on the general problem, but specifics vary with the locale. In much of the east and midwest, overall quantities are adequate, but outrageous pollution has severely restricted access to water of acceptable quality. In parts of the west, even water of questionable quality is in short supply. On a more localized basis, attention often centers on inadequate storage facilities, inefficient water use practices, or intense competition among would-be users.

In response to the growing demands for action to improve our water resource management, the Federal Congress in 1964 passed the Water Resources Research Act. The purpose of the Act is "to stimulate, sponsor, provide for, and supplement present programs for the conduct of research, investigations, experiments, and the training of scientists in the fields of water and of resources which affect water."

The Act authorized a center or institute in each of the several states. This was done to facilitate attention to the specific conditions and needs of the respective states as well as to help solve the national problem. Each institute is to plan and conduct (and/or arrange for a component or components of the college or university with which it is affiliated to conduct) competent research in relation to water resources. The research may be of either a basic or practical nature and should serve as a vehicle for training additional water-oriented scientists. The Office of Water Resources Research in the Department of the Interior has been charged with supervising the general program. Dr. Roland R. Renne, formerly President of Montana State University, was named the first director.

Utah State University was designated by Governor Clyde as the official water research agency for Utah. Once certified as complying with the requirements of the Act, the Utah Center for Water Resources Research was eligible for its initial allotment. The Center began its research operations on May 7, 1965 when \$75,000 was received to support the first approved projects. The current annual expenditure is approximately \$250,000.

At the University level, the Center is administered by a Council composed of the deans of the Colleges of Agriculture; Engineering; Natural Resources and Science; the Director of the Utah Water Research Laboratory; the Director of the Utah Agricultural Experiment Station; and the Vice President for Research. The chairman is the Dean of Engineering, Dean F. Peterson. Howard B. Peterson is Executive Secretary.

Fundable research can range from economic, social, and legal aspects of water use, to storage, quality, and transportation problems. Project proposals may be submitted to the Council by any qualified investigator in the State of Utah. The council then screens the proposals and either funds them with available monies, or recommends them for other sources of financial support. Work currently being done within the Utah Center includes projects such as:

1. Cultural, Social Organizational, and Social Psychological Factors Associated with Proposed Changes in Water Use Patterns
2. Biological, Chemical, and Physical Nature of Water Quality Factors Under Utah Conditions
3. Instrumentation and Development of Techniques to Measure and Evaluate Meteorological Problems Important to Hydrology
4. Design and Calibration of Submerged Open Channel Flow Measurement Structures

5. The Value of Water in Complementary Industry Complexes

6. Application of Electric Analog Devices to Solution of Hydrologic and River-Basin-Planning Problems

7. Recreational Value of Water in a Mutually Exclusive Setting

8. Economic Effects of Water Allocation Among Alternative Industrial Uses

The last mentioned project is being conducted by the Bureau of Economic and Business Research at the University of Utah.

Advisory committees representing local water resources agencies are being formed to help the Utah Center for Water Resources Research keep abreast of local and regional water problems and needs for research. In addition, advice will be sought from groups that are commonly considered "action agencies." Such help is expected to keep the general character of the research program geared to meet critical state needs and to provide a coordinated focus for water resources activities in the state.

Free of the immediate pressure of having to pursue "action programs," the Center can concentrate on assembling and efficiently applying the diverse disciplinary skills required for full solution of specific state water problems. By encouraging graduate student participation in the research, the Center helps produce the skilled water scientists that will be needed to conduct future water resource programs. Last year 47 graduate and 21 undergraduate students were involved in research at the Utah Center.

The water research centers in each state were created in the tradition of Federal support for land-grant university research. That tradition began with the Hatch Act and the cooperative Federal-State agricultural experiment station program, which has proven immensely productive.

The Water Resources Research Centers provide similar, practical coordination of the biological, engineering, physical, and social sciences that must function conjointly in solving local and regional water problems. The Utah Center is organized to effect such a strong multidisciplinary approach. This new capability is expected to result in major steps toward the solution of present and potential water problems of the area.

Fine fish catcher found

A USU scientist has found a new fish killer. This is not a conventional poison, however, but comes in the form of a new processed cheese. The new cheese, molded around a treble hook, will be the last piece of food many fish will swallow this coming season.

Shortly after Professor C. Anthon Ernstrom moved to Logan in 1965, he was invited on a fishing trip at Flaming Gorge. When the fishermen walked into the sports shop at Vernal to purchase some tackle they noticed a large pyramid of processed cheese stacked on the floor. When Professor Ernstrom asked what cheese was doing in a tackle shop, he was told that this was the ideal bait for fishing Flaming Gorge Lake.

That afternoon they found that this new bait was effective, but it had several disadvantages. In the warm afternoon temperatures the cheese became soft, greasy, and failed to stay on the hook. On long

casts the bait went sailing on its merry way while the bare hook dropped into the water. Professor Ernstrom remarked at the time that certainly something could be done to solve these frustrating problems.

CHEESY IDEA

Several weeks later, Dr. Ernstrom mentioned the fishing trip to a colleague, A. J. Morris, of the Dairy Science Department. The subject of a more suitable cheese for fishing was casually discussed. The conversation sparked an idea for a processed cheese designed especially for fishing use, and Professor Morris went to the Nelson-Ricks Creamery in Salt Lake City and talked to the company officials. They liked his ideas and offered to pay for all research costs to develop such a product.

The creamery supplied the basic formula for their processed cheese

and gave several suggestions for its modification. This started the "pot boiling" at USU.

Several batches of the modified formula were run, all of which were too sticky and soft. Dr. Ernstrom tried a new emulsifying salt and made some other changes in the next batch and the resulting product had definite advantages for "ye olde angler". It molds like putty, clings tightly to the hook even when warm, and leaves very little fatty residue. It was tried out on a limited scale last fishing season with encouraging results.

The Salt Lake creamery is definitely interested in the new cheese and plans to market it in 8-ounce jars.

Dr. Ernstrom does not think that the ultimate has been reached, however. He feels that the new product can be improved, and a thorough customer-use-and-reaction study will be conducted this summer.

THE PEOPLE FACTOR AND WATER RESOURCES RESEARCH

WADE H. ANDREWS

THE USU PROGRAM

Optimum use and development of the nation's water obviously requires continued advances in science and technology. Usually, however, technological progress is possible long before people are willing to change their established ways of thinking and acting. People and their social institutions (such as law) thus are as vital to efficient water management as are technological developments.

In fact, engineering experts say that the technical knowledge already available could increase water use efficiency in agriculture in Utah by 20 to 50 percent. This means that up to 50 percent of the total water used in irrigation in Utah could go for additional agricultural use or otherwise benefit the economy if all available technical know-how were applied.

The problems associated with such low efficiency ratings are especially critical in arid areas where water is often the most limiting resource. Even when water is admittedly scarce, however, its relative scarcity depends upon those who use it. In effect, the degree of scarcity correlates rather closely with the readiness of users to adopt improved methods of use and management. And people in general tend to resist any exhortations to change their "ways." We seem to prefer comfortable habits even when we know they are costly in terms of time and money.

WADE H. ANDREWS is a Professor of sociology and water resources research in the Department of Sociology, Social Work, and Anthropology.

Recognition of the importance of this "people factor" has prompted introduction of another approach to water resource research at Utah State University. During the past half-century, USU water research has primarily centered on the engineering, conservation, agricultural, biological, physical and economic considerations.

In 1965, the Department of Sociology and the College of Business and Social Science joined with the Utah Center for Water Resources Research to mobilize a capability for this important aspect of research

at Utah State University. Since then, the "people factor" has been receiving direct attention.

The USU program to study human behavior associated with water resources was the first of its kind to be activated anywhere. Sociologists are teaming up with agricultural engineers, civil engineers, foresters, recreationists, and other scientists. It is hoped that by integrating sociological analyses with other kinds of research projects, practical solutions can be found for the problem of resistance to change.

INITIAL DIRECTIONS

All of the questions about the



Figure 1. The Bear River flows through three states — Wyoming, Idaho, and Utah. It terminates in a bay — a bird refuge — of the Great Salt Lake as shown in this air photo.



Figure 2. To study human behavior associated with water resources, interviewers talk with users and ask their opinions.

"people factor" aspects of water use seem equally urgent. For example: Why do patterns of organization and water use persist even though they are wasteful, often require excessive amounts of hard labor, and in some instances are clearly uneconomical? Why are water users as well as water management and regulating organizations so often reluctant to implement changes that would provide more water? What social forces tend to foster (or hinder) water resource development in various areas?

A research project, however, has to be restricted to a relatively specific problem if it is to develop worthwhile information. The USU scientists therefore, decided to concentrate first on the Bear River Basin. Their study in progress is designed to try to define attitudes, organizations, and activities of farm and non-farm users of Bear River water. As the first of a series of basic studies, this work is helping to perfect survey techniques as well as gain information.

The random-sample interviews of people in the Bear River area have been completed. Questions were asked to obtain opinions about the use of water in the Bear River Basin. The results are now being tabulated and interpreted.

FUTURE PLANS

Recreational uses of water are of increasing concern throughout the



Figure 3. Not only residential water users must be contacted, but the farmer must be interviewed to find out how he uses his water resources.

nation. In conjunction with economists, recreation specialists, and others, the USU sociologists hope to investigate the characteristics, attitudes, needs and use patterns of individuals, families, and groups relative to water-oriented recreation. Such studies should lay the basis for predicting effects of recreational development of water resources on communities and on traditional uses of water.

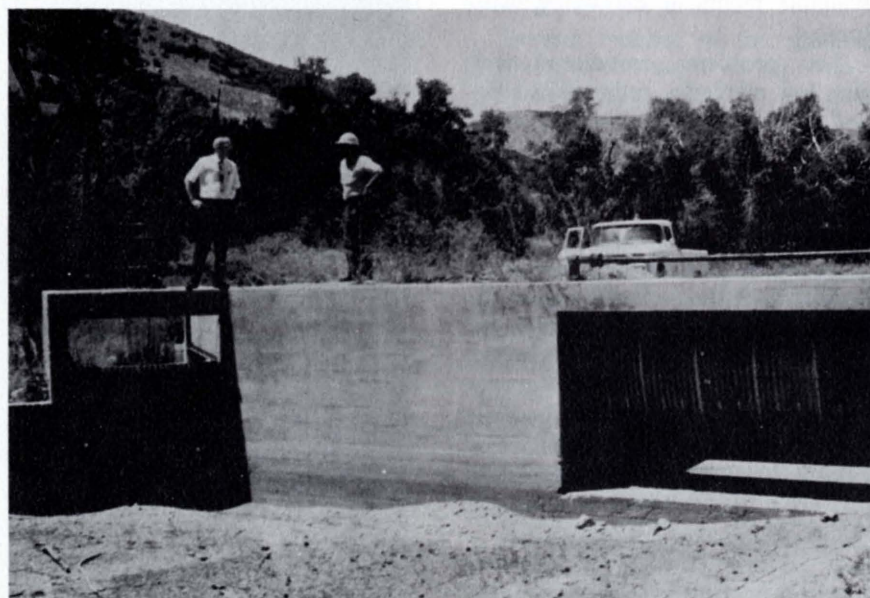


Figure 4. Cities, both large and small, die without water. This diversion dam for winter and spring run off from Mantua Dam, serves the Brigham City water complex. The right gate sends water into the diversion canal to the reservoir and the left gate turns water into the natural stream channel.



PROTECT your WATER, SOIL, and AIR—our basic natural resources—from accidental contamination by pesticides or other chemicals on the farm, in the forest, or in the city.

As the research program gains momentum, diverse areas of water research associated with human needs and social behavior will be investigated. These are likely to include: (1) changes in society caused by pollution of water sources, including social causes of pollution, and social needs and goals affecting attempts to regulate pollution; (2) social implications of legal and other regulations imposed on water resources, as these interact with customary or institutionalized patterns of behavior related to water; (3) the social changes inherent in an area; and (4) social-psychological aspects of values and attitudes that affect water use.

From Sewage to Clean Water

JOHN M. NEUHOLD, FREDERICK J. POST, and NORMAN B. JONES

Utah has a population of about 1 million that is concentrated on less than 10 percent of the land area of the state. This 10 percent naturally coincides with areas of water accessibility. Thus, Utah's growth — agricultural, industrial, and economic — is directly linked to the quantity and quality of her water resources. The problem of water quantity has always existed in this semi-arid state, but the problem of water quality is a more recent concern. Its importance increases each year.

Most irrigation water, if proper irrigation practices are followed, is utilized by the crops or is held in the soil. A portion of it, however, does return to the stream bed. By contrast, much of the water that passes through the cities is returned to streams, but as waste (or pol-

luted) water. In both cases the returning water has been altered in purity. This is especially true when the water has been used for domestic purposes and leaves the community as sewage.

SOME CONSIDERATIONS

Sewage, comprised mostly of human excrement, urine, and ground garbage, is 99 percent water. The other 1 percent causes a lot of trouble, however. The problem of handling sewage has been with cities throughout the history of civilization. As our cities grow, the problem is intensified because polluted waters no longer are expendable. They must be purified and reused — not just for irrigation or industrial use, but for human consumption.

In some areas of the United States, this reuse of water is a common occurrence because of economic necessity. To Utahns the concept is new, but it must be faced and preparations made to recycle our used water. We must recognize that sewage polluted waters are unpleasant, unhealthy, and generally uneconomical.

Under ideal conditions — free-flowing streams or large bodies of water — the organic matter in sewage is attacked by bacteria and converted into phosphates, nitrates, carbonates, and simple organic compounds. However, if this natural

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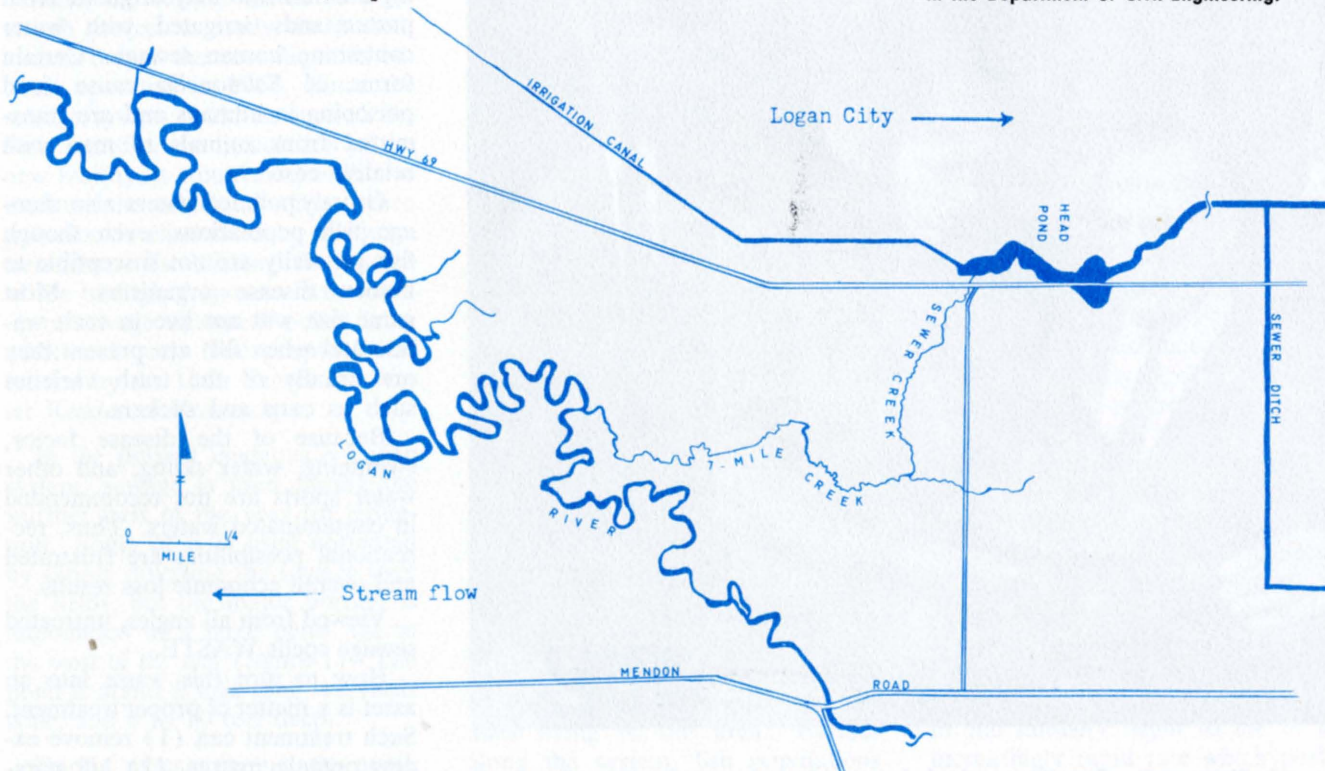


Figure 1. Study area, showing the receiving waters for Logan City sewage.



Figure 2. The measurement of water flow through the Logan sewage system helps researchers to understand sewage dilution problems.



Figure 3. Water quality affects the growth of algae (moss) on stream rocks. Research assistant, Gary Beers, explains the growth of algae on an experimental concrete form.

process is hindered, strong putrid odors result and black scums appear. The solids settle to the bottom and the water becomes foul and unusable.

More urgent than the aesthetic considerations, however, is the disease potential of the contaminated waters. Human feces equals disease. Many human and animal diseases and parasites are transmitted through excrement. Because of this, many states have enacted laws which prohibit the use of sewage on vegetable crops and only treated sewage can be dispensed on grain crops.

The chief danger of using sewage-polluted waters for pastureland irrigation is the transference of tapeworms and various other parasitic worms to livestock. Although meat inspection has nearly eliminated meat as general source of infestation in humans, worm passage to and from domestic animals is still common and causes great economic loss because the infected animals are unthrifty and make poor gains.

A number of different *Salmonella* infections of cattle and other grazing animals also may originate from pasturelands irrigated with water containing human sewage. Certain forms of *Salmonella* cause food poisoning in humans and are transmitted from animals to man with relative ease.

Grossly polluted waters also damage fish populations, even though fish generally are not susceptible to human disease organisms. Most game fish will not live in such waters and when fish are present they are usually of the trash varieties such as carp and suckers.

Because of the disease factor, swimming, water skiing, and other water sports are not recommended in contaminated waters. Thus, recreational possibilities are frustrated and overall economic loss results.

Viewed from all angles, untreated sewage spells WASTE.

How to turn this waste into an asset is a matter of proper treatment. Such treatment can (1) remove excess organic matter, (2) kill parasites and disease organisms, and

(3) remove the odors associated with sewage. These results can be obtained by processes which include mechanical plants, trickle filters, and sewage-treatment lagoons.

RESEARCH PROJECT

Logan City has long had an open sewer outflow system composed of sewer ditches, a pond, a small natural stream and finally the Logan River. However, as the city grew, the system became even more inadequate to handle the increased sewage load.

Just how sewage is purified in a lagoon system is an intriguing ecological process which has interested Utah State University researchers. A chance to study the ecology of lagoon sewage treatment was afforded when Logan City realized its present facility was inadequate. City officials proposed a completely closed sewage collection system which would include a series of treatment lagoons covering 470 acres.

In 1965, when the plans became definite, the authors instituted a research project to study the present system before the new facilities become operative in 1967. Since the sewage system could be studied before and after the installation of the new facility, it would be possible to evaluate the ecological effects when pollution is eliminated by adequate treatment. Establishing the nature of the biological systems that develop in sewage treatment ponds is an additional goal. The proposal was funded by the Utah Center for Water Resources Research.

In the present inadequate Logan system, sewage is used during the warmer part of the year for irrigation. Some of it is used untreated by simply diverting the sewage over the fields, but the major portion is impounded in a large pond just to the west of the city (figure 1). The pond is about 1 mile long, 12 yards wide, and 8 to 10 feet deep.

During passage through this pond, larger particles in the sewage have a



Figure 4. The collection of invertebrates is an integral part of understanding the relationship of stream life to sewage.

chance to settle out and digestion occurs. Tremendous amounts of algae grow in this water and supply oxygen to the bacteria which convert the organic matter into phosphates and nitrates. During the winter, the pond is emptied and sewage is discharged without settling or treatment into the Logan River and ultimately into Cutler Reservoir.

Beyond the pond, the phosphates and nitrates and some of the elemental organic materials are utilized by the plants and invertebrate animals living in the area. Farther along the system, fish populations begin to make their appearance.

BACTERIAL POPULATIONS

The upper section of the study area is comprised principally of the sewage ditch, which contains sewage that is only partly digested. What is digested sustains the growth of a filamentous type of bacteria (*Sphaerotilus*), that grows attached to the bottom of the sewer ditch in large mats. Most of the larger particulate matter settles out only after the sewage reaches the pond, however.

Bacterial studies have indicated that in early or middle May the coliform bacteria as well as the *Enterococci* (both from the intestinal tract of the human) begin to die at an increasingly rapid rate which peaks during August. During these warm

months, the biological activity of the pond is highest. Biological activity includes the growth of algae, small animals of various kinds, and the bacteria that break down organic matter. Apparently all this activity causes the death of a vast number of coliforms and *Enterococci*, and presumably of pathogens and parasites as well. After about August 10, the death rate of these organisms gradually declines until about the middle of October. At that time, samples from the pond contain very nearly as many of these potentially dangerous organisms as does raw sewage. This condition remains stable until the following May.

There appears to be some decrease of these organisms as the water passes through the pond, even in mid-winter. This decrease is small, however, and probably results from settling. In summer, the decrease is a hundred to a thousand times that of winter. As a result, water drawn from the pond for irrigation purposes is of much better quality than the water flowing into the pond. Simple treatment has thus improved the quality of the water significantly during the summer months. While the water still can not be considered safe for the use of people, it is of far better quality than raw sewage.

The change in the bacterial population of the pond is directly related to the change in the nitrate concentration of the water. The nitrate concentration of the outflow is markedly less than that of the inflow. Presumably, this results because the nitrates are incorporated into the algae biomass.

Close to the pond, relatively few animal organisms are produced, and these are mainly sewer worms and midge larvae found in the bottom sediments. Farther down stream the quality of the bottom organisms changes markedly. May flies and stone flies, as well as other forms of aquatic invertebrates, begin to appear and in the Logan River proper some 27 different species are found.

PRESENT CONDITIONS

The peak flow occurs during mid-summer in the upper part of the stream exiting from the pond. This is concurrent with increased irrigation in the city of Logan and in pastures below the pond. Very little sewage enters directly into the Logan River during the summer months.

During the winter, however, the gates on the pond are opened and a much greater volume of raw sewage reaches the Logan River. Large sewage particles then gradually settle out in the pool areas of the Logan River. Because of the lower temperature at this time of the year, the digestion rate of these particles

is extremely slow and remains so until the water begins to warm in the spring.

The net result of the existing overall pattern of sewage deposition and water flow is a polluted condition downstream from the point of sewage inflow. During the winter, this pollution drives most fish populations from the area or suffocates them through oxygen deprivation. Under the more favorable warm weather conditions, however, the area supports a very large population of fish among which are included the carp, the yellow perch, the Rocky Mountain white fish and the brown trout.

(Continued on page 31)

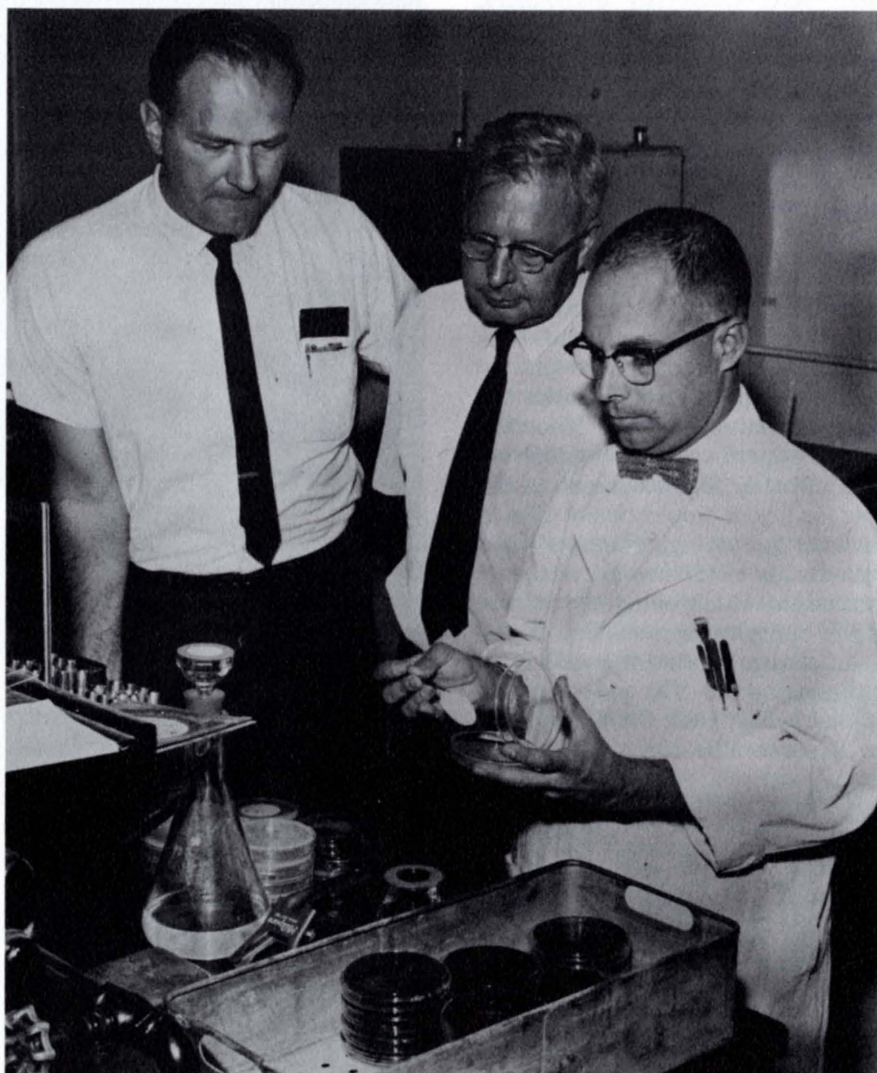


Figure 5. Bacteriological techniques are utilized to determine the contamination of sewage waters.

Development of a Low-Cost Hydrologic Sensing-Telemetering System

DUANE G. CHADWICK

Technology has advanced to the point where practically any type of information can be telemetered via radio waves. Despite the great technological achievements, which have changed telephone systems and made space travel possible, little equipment has been available for the extensive telemetering of hydrologic information from remote regions. Although there is an increasing need for watershed information, it still is obtained largely by laborious hand methods. The reason for this has been chiefly economic. Until now the high cost of telemetering equipment has prohibited the installation of networks, with sensing elements sufficiently close together to provide adequate representation of areas which experience high meteorological variability. The network-density problem is particularly serious in mountainous regions where terrain plays a significant role in this high variability in hydrologic and meteorological phenomena.

The criterion for the telemetering of hydrologic and meteorologic information is, "are the data worth the cost?" Too many times the answer to this question is negative because the cost is too high. Consequently, the development of reliable, low-cost equipment for the remote sensing and transmission of data will make possible further advancement of hydrologic and mete-

orological knowledge from inaccessible regions.

The hydrologic instrumentation and telemetering (T/M) system developed at the Utah Water Research Laboratory¹ incorporates many desirable features, including low power consumption, high reliability, minimum maintenance, and low acquisition and operating costs. The system was designed for unattended use in remote mountainous regions, operation for indefinitely long periods of time without maintenance, and without appreciable degradation of accuracy. The low-cost system design is particularly important because it permits the installation of more stations which in turn give much more information about the

hydrology of the geographical area under study.

An essential element of the T/M system is that it be completely reliable. One technique for achieving reliability is the use of a basic sensor which is free of friction and, therefore, will not wear out. The sensor² consists mainly of a metal plunger which can be lowered or raised inside a wire coil without rubbing. Tests have shown this system to be stable, free of friction, of high resolution, and economical. In addition, it can be used to measure nearly any physical quantity.

¹ This work on remote sensing and telemetering is supported by Utah Center for Water Resources Research and the Soil Conservation Service.

² Developed in the Utah Water Research Laboratory.

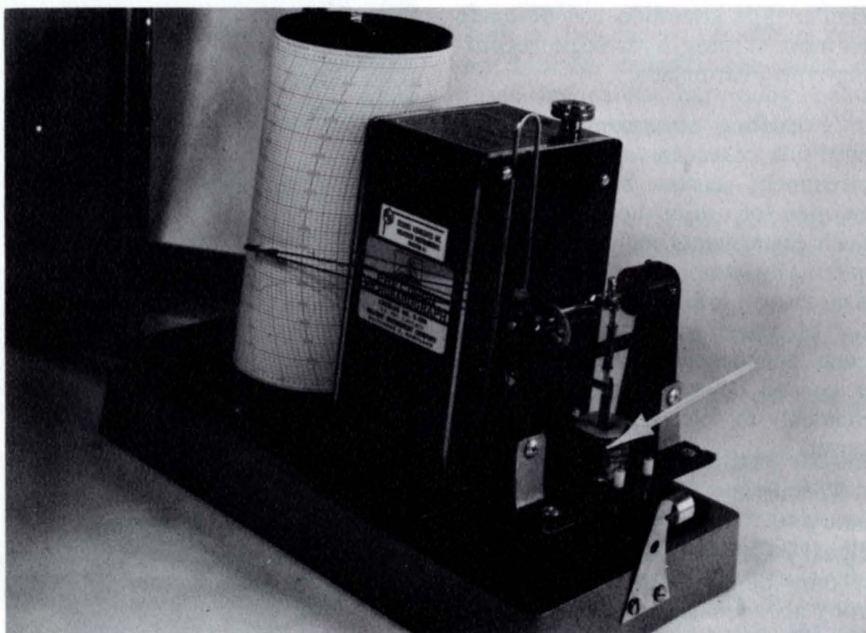


Figure 1. Microbarograph with adapted coil and plunger (indicated by arrow).

DUANE G. CHADWICK, is an Associate Professor in the Department of Electrical Engineering assigned full-time to Utah Water Research Laboratory.



Figure 2. Snow pressure pillows — a conventional pillow is the large white pillow on the left. Experimental pillows are in the right foreground.

Figure 1 shows how a microbarograph, used for measuring barometric pressure, was adapted with a variable inductance pickup. With this modification, it is ready for remote telemetering. As barometric pressure changes, the coil inductance changes. This in turn changes the musical pitch of an audio tone. The pitch or frequency of the audio tone represents barometric pressure, and a corresponding radio signal is transmitted to the base station. A similar type alteration can be made to most existing hydrologic recording-type instruments.

If existing instruments are too costly or otherwise unsuitable, new instrument sensors have been developed for use in the T/M system. Such instruments include those for measuring temperature, solar radiation, stream levels, and evaporation. All of these instruments use the same inexpensive variable inductance coil device as the basic mechanical - to - electrical signal converter.

To measure the water content of snow, a "snow pillow" is used. Figure 2 illustrates the various kinds of snow pillows being evaluated, by using the new telemetering system. These pillows, containing alcohol, normally lie beneath the snow. The

snow weight is measured electrically when the liquid within the pillow exerts pressure on a bellows connected to the pillow through a rubber hose. Liquid pressure extends

the bellows and moves the plunger in the coil. The resulting audio tone has a pitch proportional to the pillow pressure. The pillow pressure is in turn proportional to the water-content of the snow lying on the pillow. A large 12-foot diameter pillow is the accepted standard for pillow measurements. Disadvantages of this large pillow are its cost and size — it holds 300 gallons of alcohol. Researchers at the Utah Water Research Laboratory are evaluating, as possible substitutes, smaller 2- and 4-foot square metal pillows which hold only 3 to 5 gallons of alcohol.

If mountains stand between the research area and the base station, a mountain-top relay (or translator) station must be used to relay the signals. This greatly increases the transmission range which is essentially line-of-sight, figure 3.

A block diagram, figure 4, illustrates the essential elements of the complete telemetering system, in-

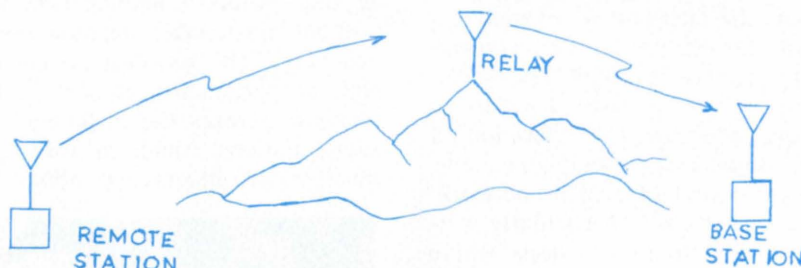


Figure 3. By use of a mountain-top relay, the total transmission range can be in excess of 200 miles under suitable conditions.

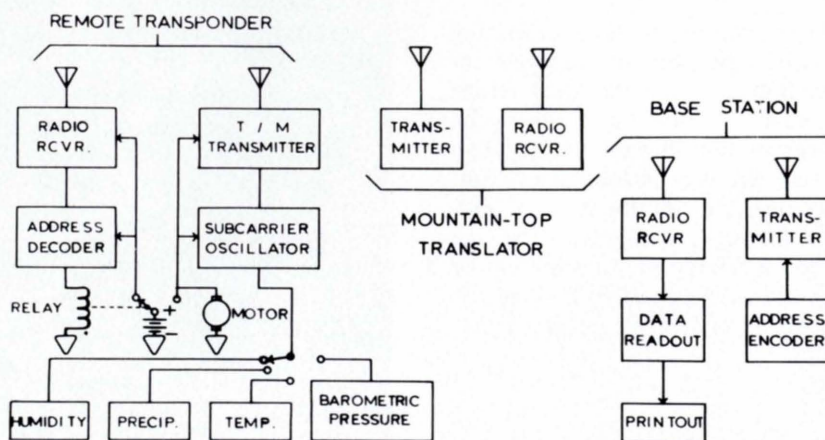


Figure 4. The telemetering system transmits multi-parameters on demand via a mountain-top translator.

cluding equipment at the remote station, the mountain-top translator, and the base station.

The base station, used for interrogation and readout, consists of a transceiver for transmitting and receiving T/M signals, an address encoder, used for interrogating the desired remote station, a frequency counter, and a tracking filter. The tracking filter permits measurement of weak signals in the presence of high levels of noise or static. Water Laboratory researchers have been successful in developing a particularly efficient working filter for use on hydrologic network systems.

A telemetering system is being installed in northern Utah for use in

evaluating the effects of weather modification as part of a project sponsored by the Bureau of Reclamation. Thirty to 40 stations will be used initially with about 200 stations scheduled for installation before the completion of the project. Figure 5 shows a typical radio reporting precipitation gage with its accompanying windshield which is used in this project.

In addition to its use in evaluating weather modification, the T/M system will have many additional benefits. It will supply information which can be useful in the more effective management of watersheds, prediction of water supplies, flood forecasting, reservoir management, and ecological studies. It may also

find use in water pollution control and the remote measurement of various water quality parameters.

Since the remote T/M unit is powered by inexpensive batteries and operates up to 1 year without attention, there should be wide application of such a device, especially in the unpopulated regions of the Rocky Mountains and the desert regions of the western United States.

Such a system also could make feasible a weather observation network which could extend from Canada to Mexico and from the Sierras to the eastern slope of the Rocky Mountains. With the appropriate selection of mountain-top relays, most of this region could be covered with either one base station or several located in the principal cities in the intermountain region. Such a system would eliminate much of the present guesswork concerning weather conditions in regions remote from the population centers.



Figure 5. Radio reporting rain gage. The can holds anti-freeze to melt the incoming snow. An oil film on the liquid prevents evaporation. The transmitting antenna is in the background.

Oxygen Controls Cherry Scald

Scald on red tart cherries can be controlled by adding oxygen to the water in soak tanks.

Cherry scald is the movement of red pigment from the skin to the flesh of the cherry. It occurs only on bruised cherries. In spite of rapid and careful harvesting, handling, and cooling, some cherries are bruised and this increases the scald danger.

Cherries are usually dumped into water tanks, called soak tanks, before pitting and processing. The soak tank provides a convenient method of cleaning, cooling, and storing large quantities of fresh cherries. It also helps cherries to firm up.

Oxygen is removed from the water by the normal respiration process of cherries. And, because respiration increases with bruising, the greater the bruising the greater the loss of oxygen. Dissolved oxygen above 2 ppm should keep scald at a minimum.



The Great

HUB OF UTAH'S

JAY M. BAGLEY, GAYLORD V. SKOGERBOE, and DONNA HIGGINS

The Great Salt Lake is becoming a more frequently discussed subject as its values become more fully appreciated and its future uses are contemplated. State planners are confronted with the problem of how the resources of Great Salt Lake can be utilized to best suit the needs of Utah's citizens.

Recent emphasis has been on developing the recreational and industrial resources of Great Salt Lake. Although the lake does have some unique features "which could be exploited as tourist and recreational attractions, the resource potential of Great Salt Lake is not restricted to these. Of particular note is that the resource potentials of the lake are not separate from the resource combinations existing within the entire drainage area tributary to the lake. For optimum economic and social benefits from future development plans, the whole resource system—not just the lake itself—should be considered. Great Salt Lake has many resources development potentials; however, this discussion will be concerned only with one of them—and its place in statewide water development.

JAY M. BAGLEY, GAYLORD V. SKOGERBOE, AND DONNA HIGGINS are Director, Assistant Research Engineer, and Editor, respectively, of the Utah Water Research Laboratory.

HYDROLOGIC SETTING

Understanding the role of Great Salt Lake in Utah's water development requires a cognizance of the lake's unique setting. An excellent description of the early exploration of the lake and its drainage area is given in the classic report, "Lake Bonneville," by G. K. Gilbert in 1890.

... In 1776 it (Great Salt Lake Basin) was penetrated by Padre Escalante from the southeast, and about the same time its southern rim was crossed by Padre Graces, but it does not appear that they discovered the peculiarity of its drainage. From about 1820 to 1835 the northern and border portion of the basin was gradually explored by Indian traders. . . . Capt. Bonneville, an army officer on leave, traveling in the interest of the fur trade but with the spirit of exploration, took notes of geographic value (1833), which were put in shape and published after a lapse of some years by Washington Irving, and his map is probably the first which represents interior drainage. . . . Fremont was engaged in his justly celebrated exploration which afforded to the world the first clear concept of the hydrography of the region. . .

The terms "peculiarity of its drainage," "interior drainage," and "hydrography of the region" used by Gilbert refer to the drainage area tributary to Great Salt Lake. The portion of the Great Basin (figure 1) which drains into Great Salt

Lake consists of much of northern and central Utah, a portion of southwestern Wyoming, southeastern Idaho, and northwestern Nevada.

Great Salt Lake constitutes the remains of prehistoric Lake Bonneville (named after Capt. Bonneville, the explorer), which at one time had a maximum depth exceeding 1,000 feet and covered an area approximately twenty times greater than the present water surface area. Being a closed drainage, the only way water can escape the lake is by evaporation from its surface.

Most of the inflow to Great Salt Lake occurs along the East Shore. The Bear River, largest source of surface water inflow to the lake, enters at the northern end of the East Shore area. The Weber River, second largest contributor of surface inflow, approaches the lake near the midpoint of the East Shore area. The Jordan River discharges into Great Salt Lake at its extreme southeast. Tooele Valley and Skull Valley drain into the southern extremity of Great Salt Lake. Limited inflow probably occurs from the Great Salt Lake Desert area west of the lake and from residual flows from the Grouse Creek, Raft River, and Deep Creek mountains which drain into the lake's northern portion.

HYDROLOGIC IMPORTANCE

Since Great Salt Lake is at "the end of the ditch," upstream tributary diversions, depletions, and return effluents, all affect the quantity, quality, and timing of water ultimately entering the lake. Each year

Salt Lake

WATER DEVELOPMENT

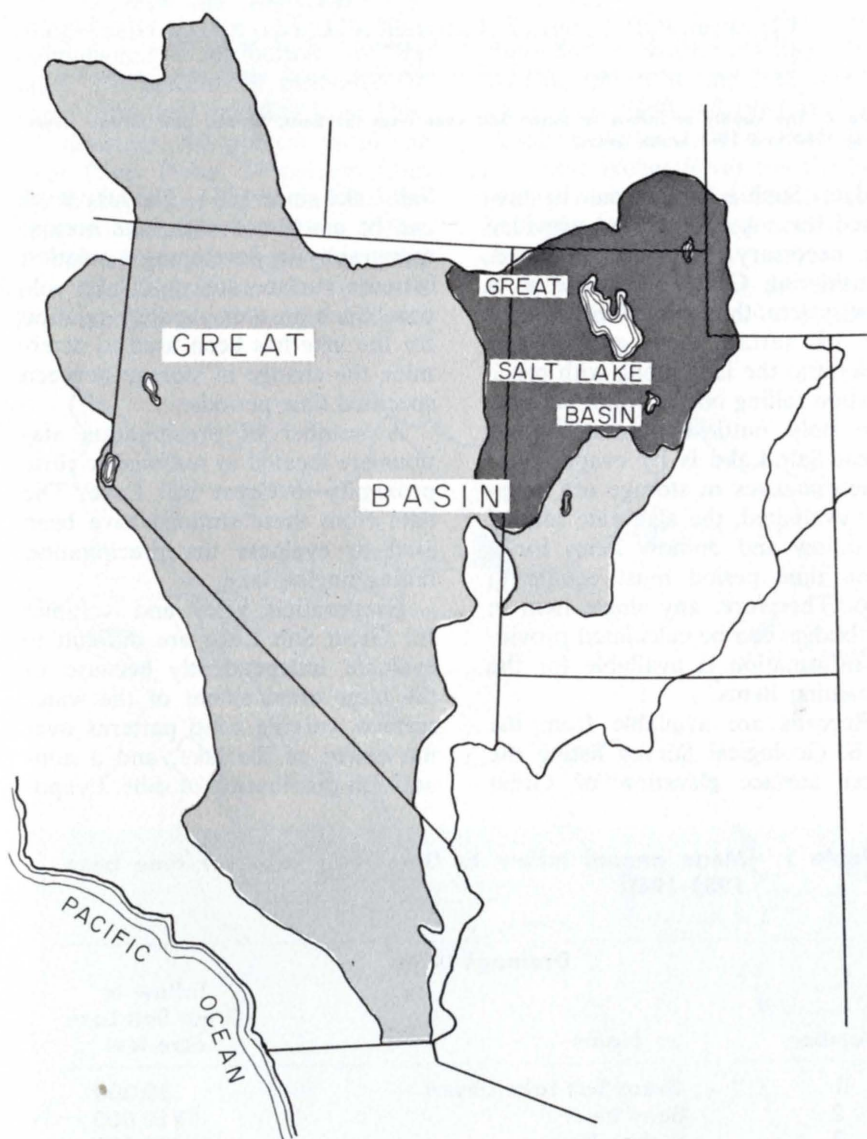


Figure 1. The Great Salt Lake Basin is a closed drainage that covers the northern third of Utah. Most of the inflow to the lake occurs along the east shore from the Bear, Weber, and Jordan rivers.

as much water as Utah's entitlement to the Colorado River flows into Great Salt Lake. Precipitation on the lake itself adds significantly to the total water received. Since all inflow must ultimately be evaporated, the volume of water now being lost through evaporation from Great Salt Lake may be almost as great as that consumed for all beneficial purposes in the entire state of Utah.

Many millions of dollars have been spent over the years in building dams, canals, diversion works, pipelines, tunnels, etc. for better control and management of our streams. It is incredible that millions have been spent on planning and development of other sources with little consideration being given to this vast resource now wasting in evaporation. The fact that the lake even exists and continues to evaporate some 2 million acre-feet of water each year is a monument to our tardiness in meeting water management challenges.

Great Salt Lake is at the very bottom of the hydrologic system which makes utilization of its resources a critical consideration. If water resource development could be planned from the headwater areas down, a high degree of utilization and efficiency of use would be possible. Once the water supplies for municipal, industrial, agricultural, and other uses have been allocated and developed in the upper reaches of a river basin, water resource planning could proceed for the areas immediately downstream with assurance that effects from

utilization in upstream regions are fully considered. Thus, as development proceeds from the top down, each successive region can be planned in such a way that all other water resources development can be carried out efficiently and in an orderly manner without future jeopardy because of upstream changes.

On the other hand, if water resource development is to proceed from the bottom up, development in the upper regions could be completely stymied because upstream utilization would affect the quantity, quality, and regimen of water available for the downstream user. The downstream development, having prior claim, would then force the continued unaltered flow in upstream regions thus reducing or even eliminating exploitation and use of water elsewhere.

In view of the restrictive consideration of the resources of Great Salt Lake, and being at the "bottom" of the resource system, careful consideration must be given to each proposal for further development in the basin in order to optimize the benefits from the entire resource system. But, analysis of the merits of any development proposal requires additional information regarding the hydrologic system of which Great Salt Lake is a vital component. Inadequate data regarding the life cycle of water through the lake has undoubtedly hindered the proper evaluation of proposed water development schemes.

GREAT SALT LAKE WATER BUDGET

Water budget analyses have been prepared for each tributary area of the Great Salt Lake Basin by staff members of the Utah Water Research Laboratory. These estimates of inflow provide valuable information for evaluating the effects of proposed water schemes on Great Salt Lake.

An accounting of the amount of water entering a system, the change in quantity of water within the system, and the amount of outflow from the system is termed a water

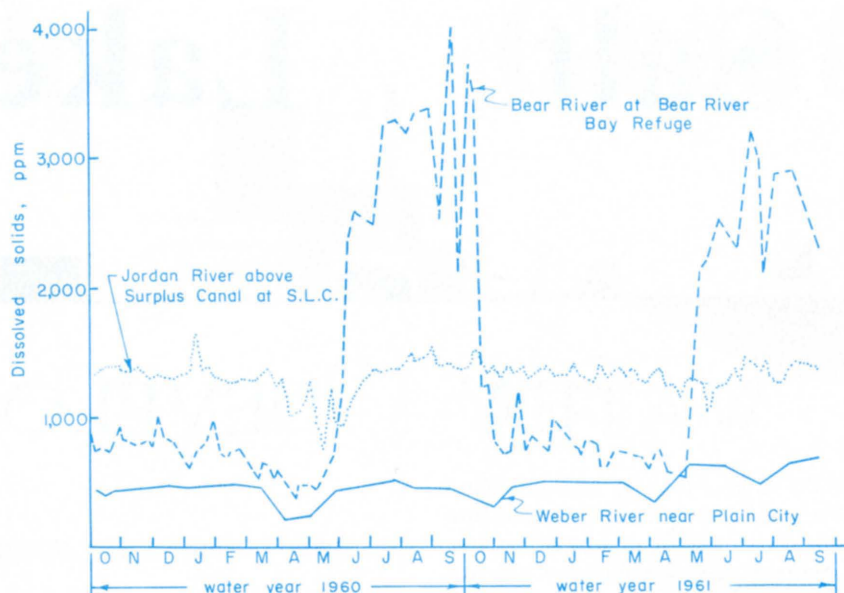


Figure 2. The quality of inflow to Great Salt Lake from the Bear, Weber, and Jordan rivers during 1960 and 1961 water years.

budget. Such a budget can be prepared for any time period provided the necessary data are obtained. Considering Great Salt Lake as a flow system, the items of inflow consist of surface and groundwater flows into the lake along with precipitation falling on the water surface. The only outflow of water from Great Salt Lake is by evaporation. When changes in storage are properly evaluated, the algebraic sum of all inflow and outflow items for a given time period must equate to zero. Therefore, any single item in the budget can be calculated provided information is available for the remaining items.

Records are available from the U. S. Geological Survey listing the water surface elevation of Great

Salt Lake since 1851. The lake level can be associated with lake bottom topography in developing a relation between surface area and lake volume. Such an area-capacity relation for the lake has been used to determine the change in storage between specified time periods.

A number of precipitation stations are located in reasonably close proximity to Great Salt Lake. The data from these stations have been used to evaluate the precipitation falling on the lake.

Evaporation rates and volumes for Great Salt Lake are difficult to evaluate independently because of the large areal extent of the water surface, varying wind patterns over the extent of the lake, and a non-uniform distribution of salts. Evapo-

Table 1. Mean annual inflow to Great Salt Lake for time base 1931-1960

Drainage Area		Inflow to Great Salt Lake acre-feet
Number	Name	
1	Great Salt Lake Desert	30,000
2	Bear River	910,000
3	Weber River	480,000
4	Jordan River	270,000
Total surface and groundwater inflow to Great Salt Lake		1,690,000

ration estimates which have been developed by a number of investigators are not in close agreement. Thus, it is necessary to determine evaporation from water budget analyses.

An evaluation of the surface and groundwater inflows to Great Salt Lake has been made for each major drainage basin tributary to the lake (table 1). These inflow averages to Great Salt Lake are based on the 30-year period from 1931 to 1960.

The water budget studies for each of the drainage areas indicate that roughly 10 percent of the total inflow to Great Salt Lake occurs as groundwater inflow. Of the total groundwater contribution to the lake, 10 percent is estimated to come from the Great Salt Lake Desert drainage, 40 percent from the Bear River Delta, 20 percent from the Weber River Delta, and 30 percent from the Jordan River Delta.

The evaporation rates occurring over Great Salt Lake were evaluated from monthly water budget analyses

over the time period 1931-1960. From this analyses, the mean annual evaporation over the lake surface is 36.8 inches which corresponds to a mean annual volume of 2,540,000 acre-feet.

WATER QUALITY OF TRIBUTARY STREAMS

Considerable data have been collected regarding the quality of surface flows in the drainage areas tributary to Great Salt Lake. The data for three major stations (Bear River at the Bear River Migratory Bird Refuge, Weber River near Plain City, and Jordan River above Surplus Canal at Salt Lake City) which indicate inflow to the lake for the water years 1960 and 1961 are illustrated in figure 2. The plots illustrate that Weber River has the best quality water as measured by concentration of dissolved solids, the concentration is fairly uniform but of lowest quality for the Jordan River, while the quality of Bear

River is more variable throughout the year being of considerably better quality during the winter than during the summer. The flows from the Weber River, plus the winter flows from the Bear River could be used for agricultural purposes without treatment. The summer flows of the Bear River and the flow from the Jordan River would probably require treatment for any expanded uses.

EFFECT OF RECLAMATION PROJECTS

In order to compare developmental alternatives and possibilities throughout the Great Salt Lake Basin drainage, it is necessary to predict or trace the effects of development all the way to the lake itself.

The Weber Basin Project, under construction by the U.S. Bureau of Reclamation for a number of years, has altered the use pattern of the Weber River. Principal features of this project are a number of reservoirs shown in figure 3. An evalua-

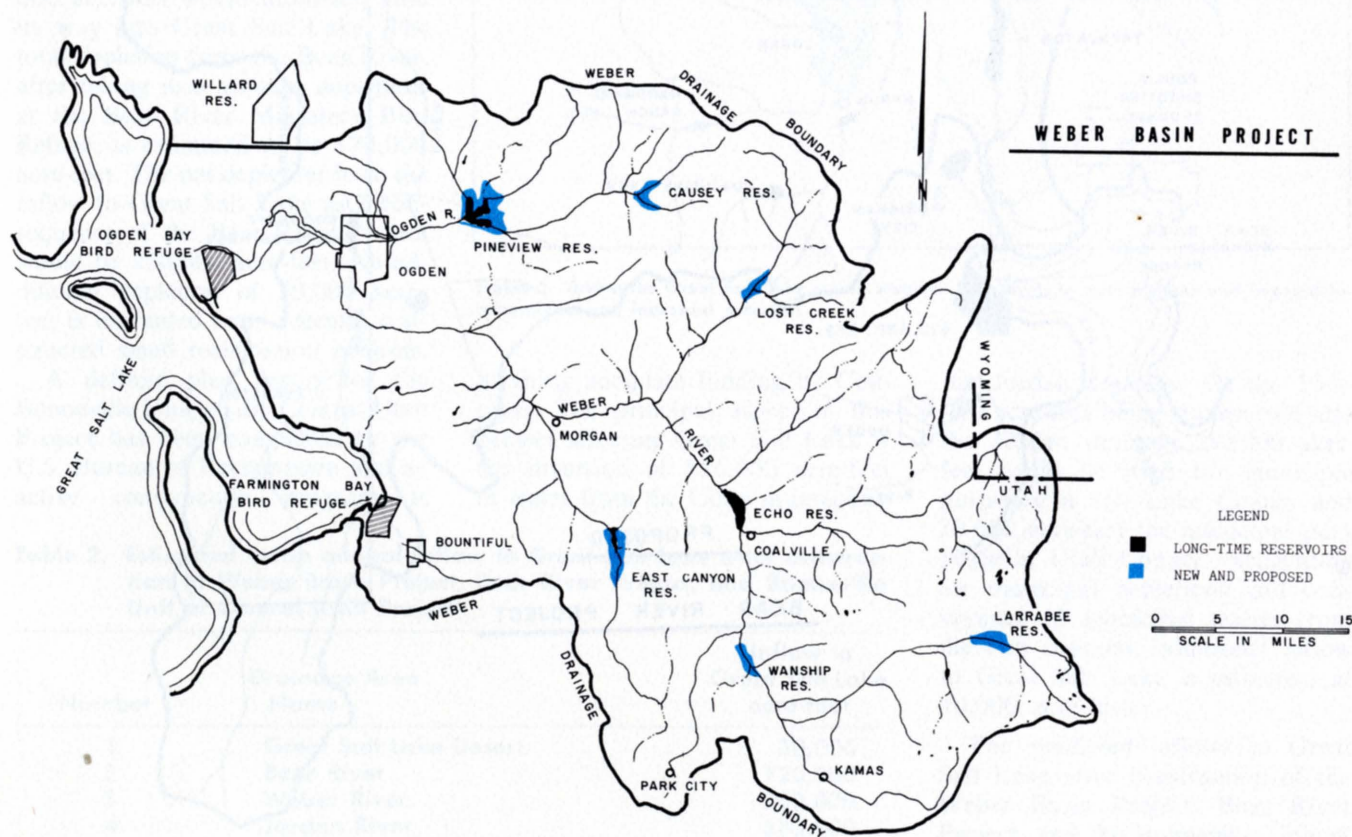


Figure 3. The Weber River Project, under construction by the U.S. Bureau of Reclamation for years, has altered the use patterns of the Weber River.

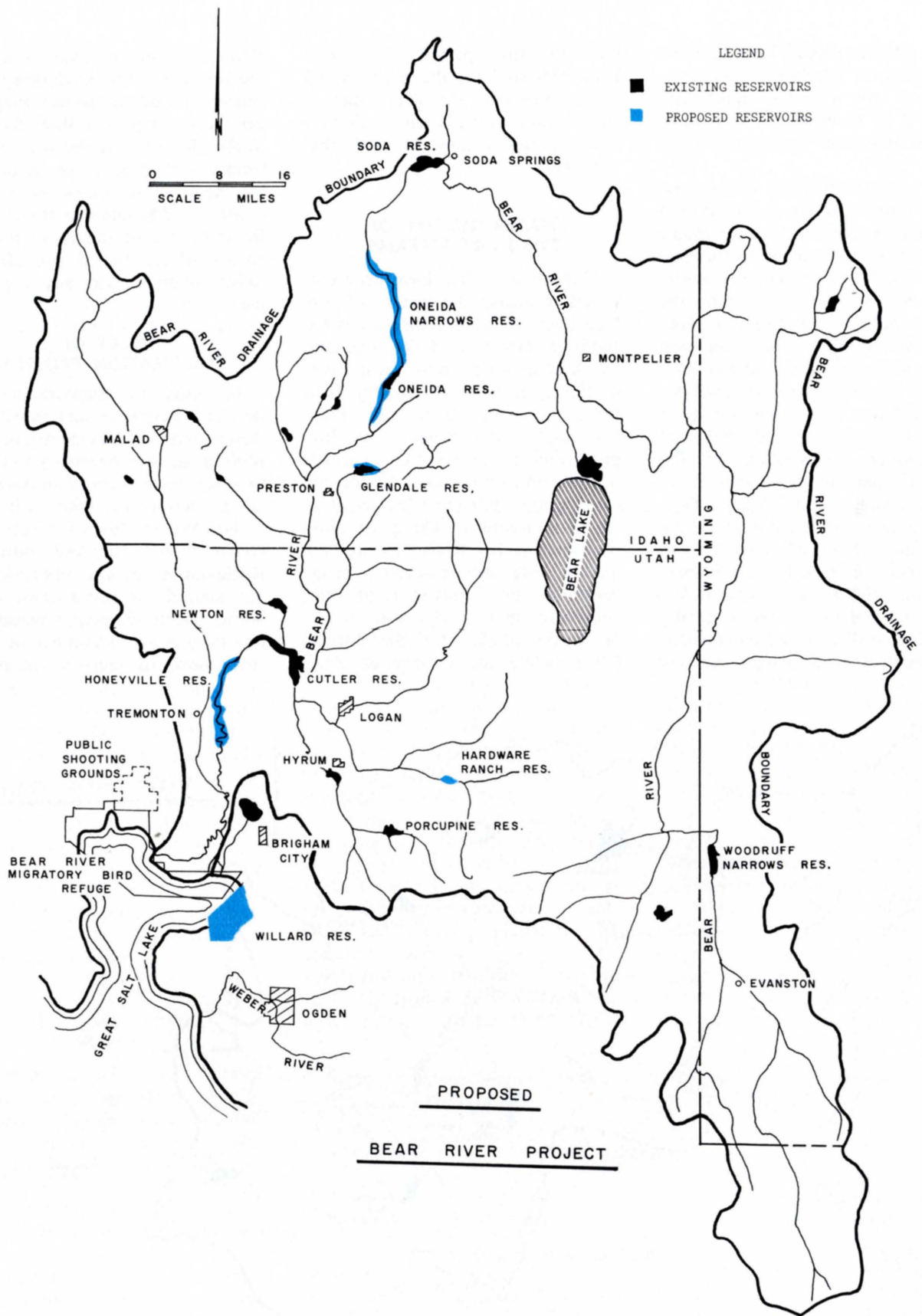


Figure 4. The Bear River Project, as proposed, will deplete approximately 150,000 acre-feet from the inflow to Great Salt Lake.

tion of the flow depletions of Great Salt Lake brought about by the construction of the Weber Basin Project indicate that about 50,000 acre-feet will be diverted to the Provo River drainage and about 200,000 acre-feet of water will be consumed within the Weber River Basin itself. Of the 50,000 acre-feet diverted to the Provo River, 20,000 acre-feet should eventually return to Great Salt Lake via the Jordan River. Consequently, the net decrease of inflow to the Great Salt Lake as a result of the Weber Basin Project will be about 230,000 acre-feet per year.

The Bear River Project is in the planning stage by the U. S. Bureau of Reclamation and it, too, contemplates depletions which will effect flows normally reaching the Great Salt Lake. Essential reservoirs being proposed for construction in this project are shown in figure 4. The project would divert 32,000 acre-feet from the Bear River drainage to the Weber River drainage (Willard Bay reservoir), of which 20,000 acre-feet would ultimately find its way into Great Salt Lake. The total depletion from the Bear River, after taking into account depletions at the Bear River Migratory Bird Refuge, is estimated to be 170,000 acre-feet. The net depletion from the inflow to Great Salt Lake as a consequence of the Bear River Project would be 150,000 acre-feet. An additional depletion of 20,000 acre-feet is estimated from recently constructed small reclamation projects.

A definite plan report for the Bonneville Unit of the Central Utah Project has been completed by the U.S. Bureau of Reclamation and an active construction program is

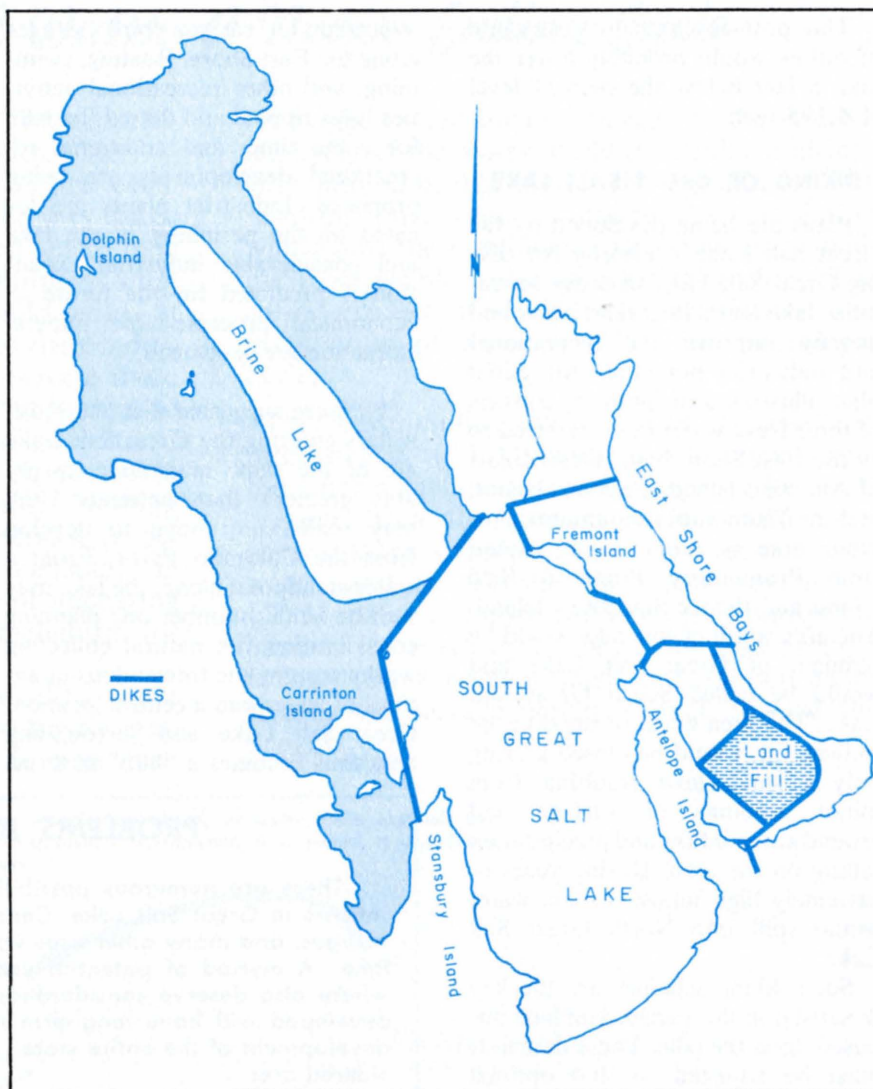


Figure 5. Diking the Great Salt Lake would stabilize lake levels in certain areas and improve its recreational and industrial potential.

awaiting adequate funding by Congress. The principal aspect of this project affecting Great Salt Lake is the diversion of 136,000 acre-feet of water from the Uinta drainage to

the Jordan drainage. Of the 136,000 acre-feet being transported into the Jordan drainage, 50,000 acre-feet could be used for municipal purposes in Salt Lake County and 20,000 acre-feet for municipal purposes in Utah County. Accounting for municipal depletions and conveyance of municipal wastes from the two counties, additional inflow to Great Salt Lake is estimated at 40,000 acre-feet.

The predicted inflows to Great Salt Lake after construction of the Weber Basin Project, Bear River Project, and the Bonneville Unit of the Central Utah Project are listed in table 2.

Table 2. Estimated mean annual inflow to Great Salt Lake after construction of Weber Basin Project, Bear River Project, and Bonneville Unit of Central Utah Project

Number	Drainage Area Name	Inflow to Great Salt Lake acre-feet
1	Great Salt Lake Desert	30,000
2	Bear River	720,000
3	Weber River	250,000
4	Jordan River	330,000
	Total surface and groundwater inflow to Great Salt Lake	1,330,000

This post-development restriction of inflow would probably lower the lake 5 feet below the present level of 4,195 feet.

DIKING OF GREAT SALT LAKE

Plans are being developed by the Great Salt Lake Authority for diking Great Salt Lake in order to stabilize lake levels in certain areas and thereby improve the recreational and industrial potential. An initial plan, illustrated in figure 5, consists of three fresh water bays, referred to as the East Shore bays, located east of Antelope Island, Fremont Island, and the Promontory mountains. Another dike is proposed to extend from Promontory Point to Bird Island and thence Stansbury Island. The area south of this dike would be remnant of Great Salt Lake and would be called South Great Salt Lake. The area north of the dike, or railway fill, would be closed leaving only a small lake resulting from minor amounts of surface and groundwater inflow and precipitation falling on the area. During years of extremely high inflow, excess water would spill into North Great Salt Lake.

Such diking schemes are the key to satisfying the varied demands imposed upon the lake. These demands must be adjusted so that optimal state benefits can accrue without completely foregoing one use to satisfy another. Only by diking arrangements which provide a means of managing water movement, storage, and lake level can the necessary control be obtained. Naturalists may oppose this form of artificial regulation but the costs of opportunities foregone if the lake were to remain in its present condition would be prohibitive.

RESOURCE DEVELOPMENT HUB

Great Salt Lake presently has many uses and these uses are expected to expand dramatically in the future. The lake is an important refuge for wildfowl. Considerable amounts of the waters to be developed by the Weber Basin Project and Bear River Project are being

allocated to various bird refuges along the East Shore. Boating, swimming, and other recreational activities have rippled and dotted the lake for some time, and additional recreational developments are being proposed. Industrial plants are located on the periphery of the lake and considerable industrial expansion is predicted for the future as economical processes for mineral extraction are developed.

We have suggested that "surplus" waters entering the Great Salt Lake are of the same magnitude (probably greater) than amounts Utah may realistically hope to develop from the Colorado River. From a water standpoint alone, the lake may well be Utah's number one planning consideration. Its natural collecting works accumulate tremendous quantities of water into a central location. Great Salt Lake and surrounding area thus becomes a "hub" in terms

of the developmental impact it may impart. Careful consideration as to the extension of economic benefits from this hub is vital.

From the mammoth natural collecting works of Great Salt Lake, the redistribution of accumulated water to water-scarce areas needs to be considered. By proper diking, storing, routing, and pumping, the inflow waters of the lake could be interconnected to each other and interlinked to other major storage facilities such as Utah Lake, Willard Bay Reservoir, Sevier Bridge Reservoir, etc. Such integrated water development could be accomplished while enhancing the overall recreational and industrial potentials that exist in the immediate vicinity of the lake. By the device of water rights exchange, made possible and practicable through such an intertie of project facilities, additional water could be made available to vast areas of the state.

PROBLEMS AND DECISIONS

There are numerous possibilities for utilizing the present water inflows to Great Salt Lake. Chemical industries, recreation, wildlife refuges, and many other uses will compete for water in or near the lake. A myriad of potential uses at water-deficient locations elsewhere also deserve consideration. How supplies are allocated and developed will have long-term impact on the economic and social development of the entire state. Some questions which must be considered are:

- What value do the people of Utah place on Great Salt Lake water use for domestic, recreational, industrial, wildfowl, or irrigation and how can these constantly changing values be evaluated and projected into the future?
- What are the physical, legal, and economic problems which affect the possible interception and utilization of water presently wasting into the Great Salt Lake?
- How can allocations of Great Salt Lake water be made to meet the demands of today and also provide for shifts in water use found desirable in the future?
- How would the establishment of a Great Salt Lake National Park or Monument affect the freedom and flexibility to manage inflow to Great Salt Lake?
- To what extent, and at what time in the future, should desalinization or other reclamation processes be initiated to extend and augment usable supplies from water now emptying into Great Salt Lake?
- To what extent would the answers to the above questions be modified if water were imported from the Columbia River Basin or Alaska and Canada?

The World of Water - A Never-Ending Cycle

This world is a water planet. Three-fourths of the earth's surface is covered with water — enough to completely cover the entire earth some 800 feet. Water has formed the very shape of the earth. Water has determined where men would settle, how fast they could multiply, what they could grow, and what they could build. It has determined their commerce and their industry, their communities, and their private lives. Water has been the cause of wars, but it has also been a common interest for peaceful pursuits.

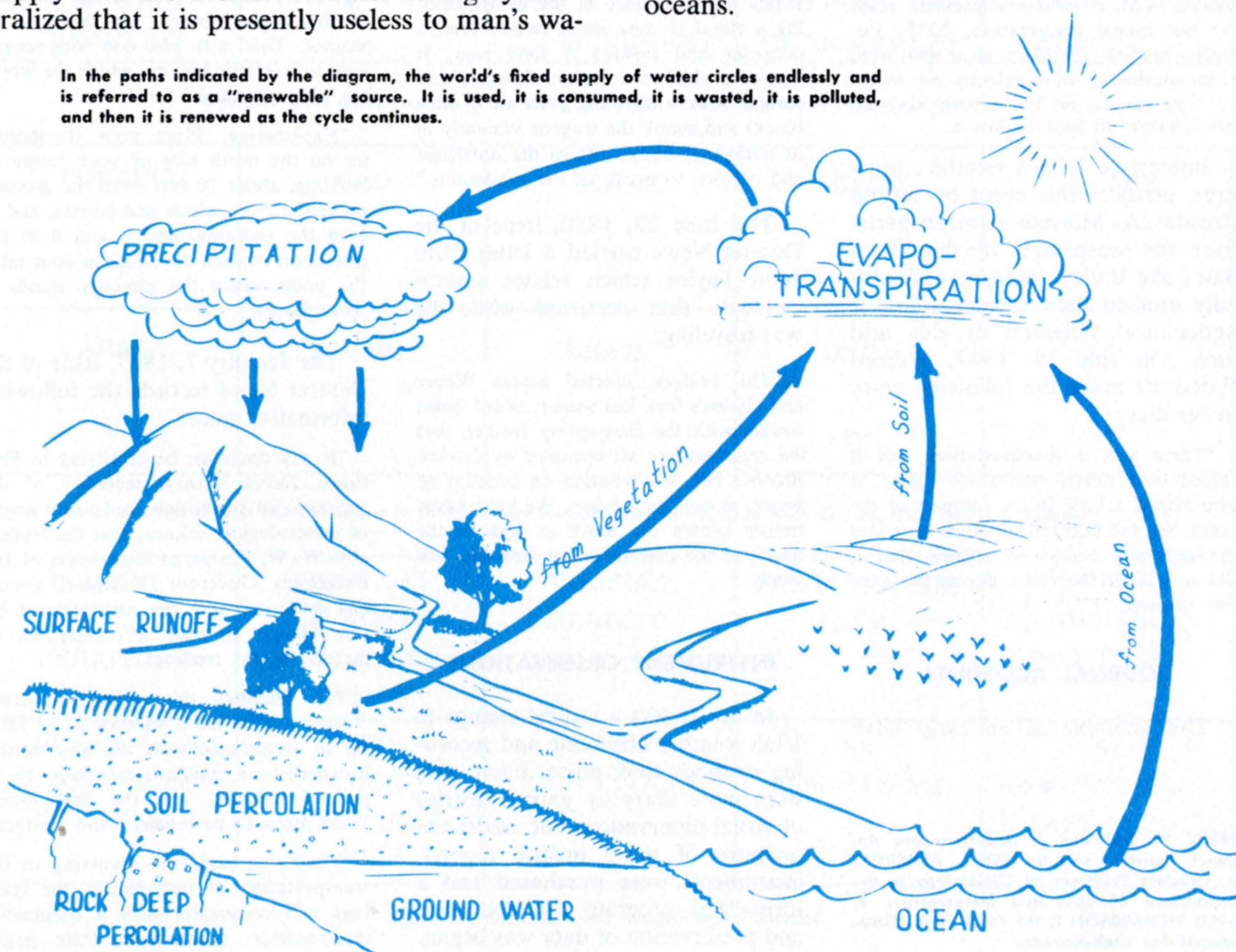
The immense supply of water on the earth and in the atmosphere is constant. Nothing man has done or can yet do will increase or decrease this quantity. Though constant in amount, the world of water is one of unceasing cyclical movement. It is a vast mechanism for distilling and redistributing itself.

The greatest portion of the world's water supply is in the oceans — water so highly mineralized that it is presently useless to man's wa-

ter needs, except for commerce. In the unceasing cycle of the water world, this salty undrinkable and unusable source is vaporized. The resulting pure vapor is carried by circulating winds into the continental land masses providing fresh usable water so essential to life. The entire process of distillation, circulation, and distribution of water is called the hydrologic cycle.

This never-ending cycle can be described in three stages. (1) Moisture is transferred from the earth's surface to the atmosphere by evaporation from the ground surface and from oceans, lakes, swamps, and other open bodies of water, and by transpiration from vegetation. (2) Moisture is transferred from the atmosphere back to the earth by condensation and precipitation. (3) A portion of the precipitated water returns via surface channels back toward the oceans.

In the paths indicated by the diagram, the world's fixed supply of water circles endlessly and is referred to as a "renewable" source. It is used, it is consumed, it is wasted, it is polluted, and then it is renewed as the cycle continues.



Its origin and destiny - - -

UTAH WEATHER REPORTING

BRENT W. BARFUSS, E. ARLO RICHARDSON, and GAYLEN L. ASHCROFT

CORRINE	CAD	BLANK	THROW	BLANK
ARAL	BLANK	BRASS	ONE	AB

This was the first official weather observation transmitted in code by telegraph for the Utah Territory. The observation was taken and transmitted by the Signal Corps on February 1, 1871, from Corrine. Decoded, the message would read:

Corrine, Utah Territory—First day of month, A.M. observation; pressure reading not taken; temperature, 20°F; humidity reading not taken; clear with wind from southwest; wind velocity not taken; no high clouds; no low clouds; and no precipitation in past 12 hours.

Interest in Utah's weather, however, predates this event by several decades. As Mormon pioneers gazed over the wastelands of the Great Salt Lake Valley, thoughts undoubtedly crossed their minds as to the agricultural potential of this arid area. On July 24, 1847, Wilford Woodruff made the following entry in his diary:

"There was a thundershower and it rained over nearly the whole valley; it also rained a little in the forepart of the night. We felt thankful for this, as it was the generally conceived opinion that it did not rain in the valley during the summer season."

JOURNAL ACCOUNTS

This example of an early Utah

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BRENT W. BARFUSS is undergraduate Research Assistant and GAYLEN L. ASHCROFT is Associate Professor of Climatology in the Department of Soils and Meteorology. E. ARLO RICHARDSON is the ESSA State Climatologist for Utah-Nevada.

weather record was followed by several years of descriptive observations.

William Clayton recorded the effects of a whirlwind in Salt Lake City on August 7, 1847:

"About noon a very large whirlwind struck the south side of the camp forming a cloud of dust about twenty feet in diameter and making a loud roar. It carried a chicken up some distance, tore up the bowers (meeting place on temple block) and shook the wagons violently in its course. It passed off to the northeast and seemed to break at the mountains."

The June 22, 1850, issue of the Deseret News carried a letter from John Taylor which relates several incidents that occurred while he was traveling:

"The bridges, erected across Weber and Ogden's fork last winter, sailed down stream with the first spring freshet; and the crossings are all occupied by ferries. Brown's fort was vacated on account of water, as our last advices. We have never before known the water as high in the basin, as the present season and the past week."

INSTRUMENT OBSERVATIONS

In the 1850's a radical change in Utah weather observing and recording methods took place. Early data were mere diary or journal entries of visual observations but, under the pressure of more precise reports, instruments were purchased and a formalized program for collection and preservation of data was begun.

The Deseret News, dated March 6, 1852, made the following plea to its readers:

"Temperature Records — Will our friends who have thermometers in the various settlements of the mountains commence a daily reading on the 21st of April, and report a copy of their readings every three months to the librarian of the Utah Library, Mr. William C. Staines. This will add one long-sought item to scientific history, which the world has hitherto sought for in vain.

"Explanation: Place your thermometer on the north side of your house or building, about 10 feet from the ground; protect it from winds and storms, and at 6 in the morning, and 2 and 9 in the afternoon of each day, note in your table the point where the mercury stands at those hours."

The January 7, 1857, issue of the Deseret News records the following informative note:

"It will doubtless be gratifying to Professor Joseph Henry, secretary of the Smithsonian Institution, and to all lovers of meteorological science, that the Honorable W. W. Phelps, at the request of His Excellency Governor (Brigham) Young, has consented with the assistance of his son, Henry, to keep a regular set of meteorological readings.

"To facilitate this object, Governor Young has caused a window to be fitted up in accordance with the Smithsonian instructions, a standard rain gage to be properly located, and the Smithsonian Wind Vane to be repaired and mounted.

"Owing to accidents occurring in the transportation of instruments, the readings will commence with a barometer, thermometer, ombrometer (rain gage),

and wind vane, and will be extended as fast as the balance of the instruments can be provided."

WEATHER FORECASTS

The Smithsonian Institution did an excellent job of collecting and preserving early instrumental weather observations. However, as the population of the nation increased, the public began to demand adequate warning of approaching storms. Since army posts were

spread throughout the states and territories, and many were equipped with telegraph facilities, it was a logical step to assign the responsibilities to the Army Signal Corps.

Under the program of the Signal Corps, observations were taken three times a day and transmitted by telegraph to central collection points where weather maps were drawn and forecasts prepared. The Army post at Corrine was part of this Signal Corps network.

The first coded message sent from

this post, reproduced at the beginning of this article, was prepared by Sergeant William McElroy. This report, like other weather reports, consisted of 10 code words arranged in two lines of five words each. Each code word represented a particular station, a definite date and time or a unique value of a specific meteorological element.

During the 1880's heavy political pressure was exerted to remove the nation's meteorological service from

STATION CODE	DATE AND TIME OF OBSERVATION	PRESSURE READING	TEMPERATURE READING	HUMIDITY READING
WEATHER CONDITION AND WIND DIRECTION	WIND VELOCITY	UPPER CLOUD COVER AND DIRECTION OF MOVEMENT	LOWER CLOUD COVER AND DIRECTION OF MOVEMENT	AMOUNT OF PRECIPITATION SINCE LAST REPORT

Figure 1. Code sequence used by the Army Signal Corps to send weather reports via telegraph.

CORRINE 1	CAD 2	BLANK 3	THROW 4	BLANK 5
ARAL 6	BLANK 7	BRASS 8	ONE 9	AB 10

Figure 2. The first official weather report in Utah. It was sent by telegraph in code from Corrine, Utah Territory, February 1, 1871.

CORRINE UTAH TERRITORY	FIRST DAY OF MONTH A.M. OBSER- VATION	PRESSURE READING NOT TAKEN	TEMPERATURE 20° F.	HUMIDITY READING NOT TAKEN
CLEAR WITH WIND FROM SOUTHWEST	WIND VELOCITY NOT TAKEN	NO HIGH CLOUDS	NO LOW CLOUDS	NO PRECIPITATION IN PAST 12 HOURS

Figure 3. This is the same weather report decoded.

military domination and place it under civilian control. After several years of effort a bill authorizing establishment of the civilian Weather Bureau under the Department of Agriculture was signed by President Benjamin Harrison on October 1, 1890. This agency took over both the observational and forecast programs of the Signal Corps.

The importance attached to weather forecasts in Utah is illustrated by the following excerpt from Bulletin 47 published in 1897 by the Utah Experiment Station.

"The Experiment Station receives the telegraphic weather forecasts from the forecast official of the Department of Agriculture located at San Francisco. The forecasts are telegraphed each day (Sundays and holidays excepted) at government expense. The signal flags are displayed from the flag pole of the College in full view of the valley below. These forecasts or warnings are of great value to the farming community.

"Great value is placed on them by the Department of Agriculture at Washington. From their timely warnings much property is saved both on sea and land. The department considers that \$10,000,000 is a conservative estimate of the value of property saved in 1895.

"Doubtless some means will be devised in the near future whereby these forecasts will be placed within the reach of every farmer in the country."

Today there are more than 14,000 official climatological weather stations in the nation. The backbone and power of this observational program is the cooperative observer who volunteers thousands of hours of service without any remuneration other than the inner feeling of a job well done.

Many families of the state have contributed years of unselfish service. The late J. M. Anderson of Manti, had the longest period of service as a Utah weather observer. He made daily observations at Manti from June 1908 until his death on September 16, 1959, a period spanning more than 50 years. His son, Leslie J. Anderson, is continuing the observational record.

Many valuable notes accompany the official reports sent in by these

trustworthy observers. The following account was sent in by Mr. Andrew W. Swanson, observer at Kanosh, Utah, since August 1947:

"The most unusual experience I have had was February 8 and 9, 1953. It started to snow early in the forenoon of February 8, got quite heavy in the after-

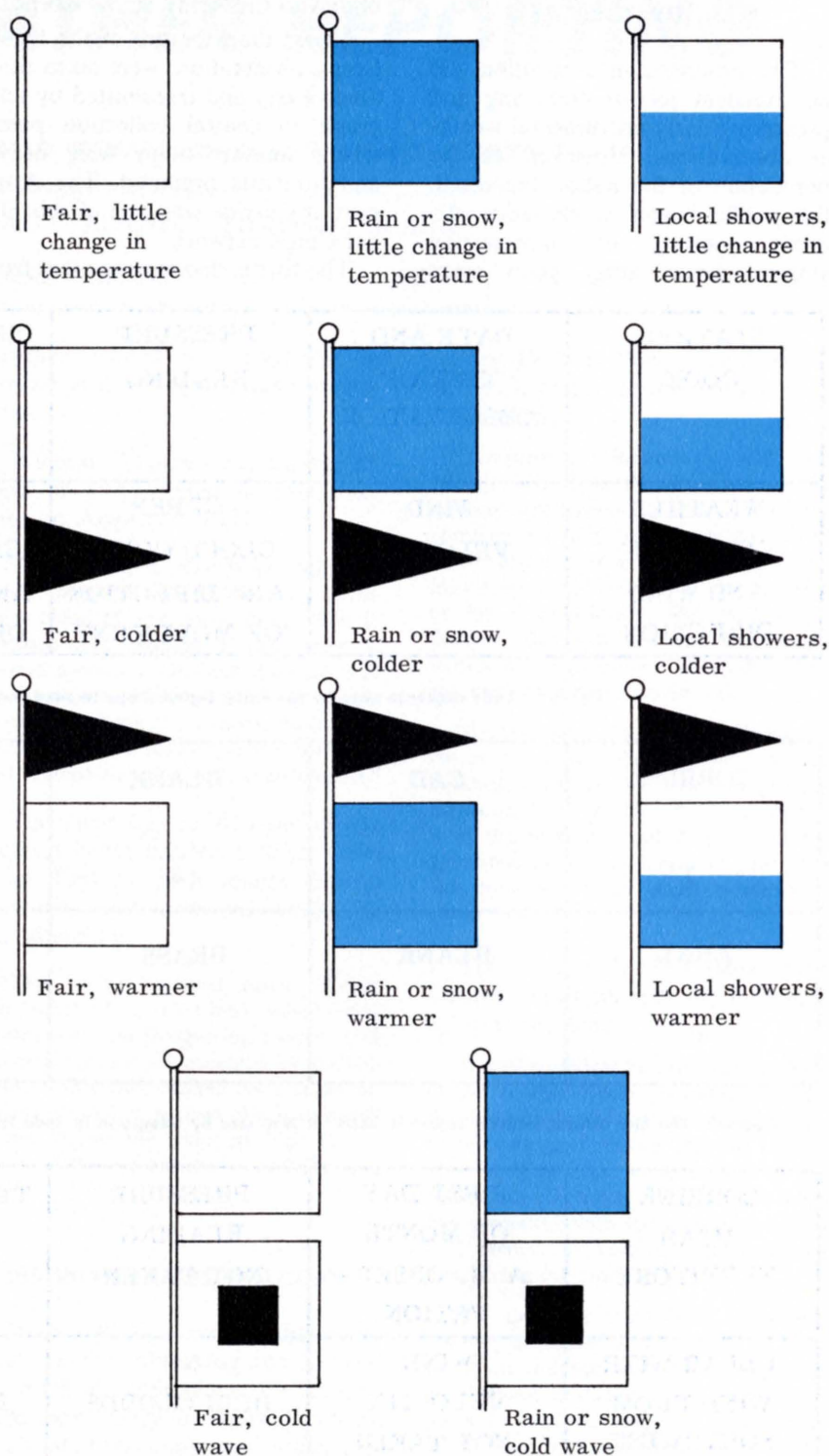


Figure 4. Before man was able to rely on mass media for weather warnings, signal flags were displayed throughout the country to forecast weather conditions. The square, blue and white flags were used to indicate the precipitation forecasts. The black triangular pennant was used to indicate temperature trends. The white flag with the black square in the center was flown with the appropriate precipitation flag when a cold wave was expected.

noon. Early evening I checked the rain gauge and found it full of snow and starting to pile up above the can, so I emptied it in a bucket. I had to repeat this again at 10:30 p.m. and by 7:00 a.m. the can was full again. The total moisture for the 24-hour period was 3.55 inches and 34 inches of snow. It continued to snow until 2:30 p.m. February 9. The sum total moisture was 4.43 inches and 40 inches of snow. No one in town could remember so much snow in one storm."

The family of Jim Crook also made a major contribution to the knowledge of Utah's climate. Jim, one of the 10 pioneer settlers of Heber, kept a daily journal of weather observations from May 1859 until 1872. At this time he sent to the Smithsonian Institution for weather instruments. He continued daily observations for the Institution until he was appointed official Weather Bureau observer in January 1893. He served the Weather Bureau faithfully until shortly before his death, which occurred at age 90 in March 1921. Observations were continued by his son, H. G. Crook, who maintained the records until his death in 1939. The present observer, Lindsay W. Crook, is a nephew of H. G. Crook and a grandson of the original observer.

The three generations of the Crook family have taken weather observations for more than 100 years. During this time there has been rapid growth and advancement in weather reporting. One hundred years ago there were only 33 official stations in the state; by 1966 there were nearly 300.

WEATHER SERVICE OF TODAY

The modern meteorological service of the United States has several major responsibilities. Among these are the accumulation and analysis of climatological data and the preparation and dissemination of forecasts.

The analysis and storage of climatological data is the responsibility of the Environmental Data Service (EDS) a division of the Environ-

mental Science Services Administration (ESSA). Climatological data is obtained from all available sources including the vast corps of cooperative observers, the paid full-time observers at first-order weather stations, and the large number of part time observers paid either by the Federal Government or local aviation interests.

Climatological observations from all of these sources are sent to Asheville, North Carolina, where a large computer is used to analyze, summarize, and prepare these data for publication. The published data are then distributed to the individual state climatologists where they are made available to user groups.

The Weather Bureau, which is another division of ESSA, collects hourly synoptic observations from several hundred stations. These data are transmitted by teletype to the National Meteorological Center at Suitland, Maryland. Here a large computer takes over and using modern mathematical techniques prepares forecast maps which are immediately transmitted to the various forecast centers. The forecasters at the state centers then prepare local and state forecasts and warnings for distribution to the public within their areas of forecast responsibility.

The Weather Bureau is making strides toward the goal of increasing the reliability and range of their products—the weather forecasts. To

make these strides, special studies are continually in progress to improve the mathematical models of the atmosphere that are used by the computer. Current models even take into consideration the way that mountains influence the weather.

To make additional improvements in the forecast service, we need a better understanding of meteorological phenomena. The weather satellite program is an important step in this direction. As of June, 1966, a total of 14 satellites had been placed in orbit and thousands of pictures returned to earth for analysis and interpretation. The first weather satellite, Tiros I, was placed in orbit in 1960. The impact of this satellite was described by V. J. Oliver in these terms:

"Meteorologists for many years have known the general nature of storms but have lacked a measure of their individuality, a 'cloud print' of the storm to identify it uniquely. Pictures taken by Tiros I now make excitingly clear the details of cloud patterns as well as the general structure of storms."

With satellites circling the earth, automated weather stations relaying precise data to centralized computers, and increased knowledge of storm mechanics the reliability and range of our weather forecasts should be markedly improved in the near future.

Considerable animosity arose among the fairer sex several years ago when the Weather Bureau adopted the policy of naming hurricanes after women. There appears, however, to be some precedence in history. The Army Signal Corps used women's names to code winds blowing from the cold north, northeast or east. The warm gentle winds from the south and southwest were named after men. West winds were named after rivers, northwest winds after seas, and a calm after trees. These names changed also to give the weather condition. For example, a heavy snow with a wind from the east would have the code name Sophia. In comparison, a wind from the east on a clear day would have Mabel as the code name.

The date and time of observation, a.m., p.m., or midnight reports, were coded with words beginning in C, G, and N. Barometer readings had the code words that began with F, whereas temperature readings began with T.

Direction of upper clouds were named after fruits, flowers, medicines, furniture, clothing, animals, birds, metals, and planets. Considering this list, women should have no cause to object to their names being associated with weather phenomena.

McDaniel Mites and the Resistance Problem in Utah

DONALD W. DAVIS

Utah's most troublesome mite in the major fruit-growing areas of the state is the McDaniel mite (*Tetranychus mcdanieli* McGregor). Some of the other spider mites, such as the brown mite are more widely distributed in Utah, and in some areas the four-spotted mite, the two-spotted mite, or the Willamette mite may predominate. However, McDaniel mite infestations are most serious from Brigham City to Payson, along the narrow fruit growing belt between the Wasatch mountains and the Great Salt Lake and Utah Lake.

The biology of this mite, in Utah, was studied by Nielsen (1957). It has since been extensively studied by workers in Washington and British Columbia.

In Utah, these mites attack apples most frequently, but they are also common on sour cherries and raspberries, and are found occasionally on other crops. A wide range of herbaceous plants serve as sources of infestation. Morning glory, milkweed, alfalfa, asparagus and others are seasonal host plants.

Some mites can be found in the central portions of trees when the first foliage shows in the spring, but most of these disappear or remain in small numbers until the hot summer weather in late June or early July. At this time many of the herbaceous plants dry up, and the McDaniel mites move into the trees; temperature and relative humidity become ideal for rapid mite reproduction at this time. During July,

August and part of September the McDaniel mites frequently reach tremendous numbers, enough to turn the entire tree a dull gray color. At 90°F they go through an entire generation in less than 10 days. During late season many bud terminals are covered by webbing. Consequently, fruit set during the following year is often drastically reduced.

MITICIDES

Detailed control studies have been conducted with the spider mites in Utah for 12 years. Each year a series of miticides has been used in

the experimental control of the McDaniel mite. Some of these materials have been new experimental chemicals, and some are established materials. Many of these materials have been effective and have been incorporated into the spray programs and have usually served well for a few seasons. Scattered examples of failure were soon noted, however, and these were often followed by general failure, both in commercial trials and experimental work. A summary of some of these case histories is shown in table 1. There are examples of resistance by the McDaniel mite to more than 20 different miticides in Utah alone. Other states have had equally serious problems.

It is clearly established that the



Figure 1. Mites are a serious problem in Utah fruit orchards. These spider mites (genus *Tetranychus*) with their eggs are representative of the pests. The actual mites are 0.5 mm long. Photo by W. P. Nye.

DONALD W. DAVIS is an Associate Professor in the Department of Zoology.

McDaniel mite has now become resistant to almost all of the chemicals available for use. This resistance may show up with closely related chemicals within one season, as it did with Guthion. More frequently we have obtained about three seasons of successful control, as we did with Kelthane and Tedion. This resistance is actually developed by the killing of the susceptible mites, while a few more hardy individuals survive. These few survivors interbreed, and the offspring are even more resistant. After a few generations, these resistant mites constitute the majority of the population. Since the McDaniel mite goes through from 10 to 15 generations a year in Utah, depending on season and location, this selection for resistance takes place very rapidly.

The obvious question is: what can we do about it? Unfortunately there is no clear-cut answer, but there are four possible approaches to the problem. We must consider them all, and make a choice, or a combination of choices.

SWITCH MATERIALS

The first approach is to switch to new materials as the mites become resistant to the older ones. This has been our standard solution during

the past 20 years since the mite resistance problem first became acute.

Two major problems indicate that this solution may not continue to be an answer. Many examples of cross-resistance have occurred. That is, mites become resistant very rapidly to related compounds. For example, in Utah, it required less than one season for parathion-resistant mites to resist Guthion. It required less than two seasons for these parathion-Guthion resistant mites to resist Ethion. Thus, the cross-resistance problem becomes more common.

The second reason for questioning this procedure is: Can new miticides be developed rapidly enough? About 15 years ago a chemical company could develop a new product, meet the legal requirements for testing, and get the product on the market in 2 to 3 years. Now that the requirements by state and federal agencies are many times more complex the process usually requires about 5 years and development costs have increased up to 3 million dollars in some cases.

During the past 2 or 3 years, very few new products have been released for general mite control. Morocide was one of the few. Morestan was also released, then part of

the recommendations were withdrawn.

ROTATE CHEMICALS

The second approach, often mentioned, is to alternate or rotate the available chemicals before the mites show resistance. In this way the usefulness of a material is not destroyed by causing a widespread resistance problem. In theory this works fairly well, but growers are highly reluctant to switch to some other material when they have found one that works. This rotation of chemicals is at best only a delaying action. It is not a permanent solution.

MIX CHEMICALS

The third suggestion is to mix chemicals of different modes of action. Theoretically, it is difficult for a mite population to cope with two things at once. The main disadvantage to this approach is cost. The concentration of each chemical must be kept at an effective level. This means that the total amount of chemical is greater, therefore, the cost to the grower goes up. Then there is some doubt whether this practice will actually delay the resistance problems very long. The mites actually may be able to cope with two materials almost as quickly as one. In that case we would end up with more of a problem than before.

CHANGE THE APPROACH

The fourth possible solution, and the one which we apparently are being forced to, is to change spray practices in such a way that predators which feed on the McDaniel mite can be preserved. Ways of doing this are being investigated in several areas of North America and Europe, but we are not yet ready to make specific recommendations.

There are several important predators which feed on mites, the most important of which seem to be other species of mites. As with insects, there are "good" mites and "bad" mites. Investigations have shown

(Continued on page 31)



Figure 2. The control of mites in Utah Orchards by using chemicals is difficult at best. One means of biological control — the use of predatory mites — is being investigated. The predatory mite shown here is *Typhlodromus occidentalis* and is about 0.38 mm long. Photo by W. P. Nye.

Feed efficiency in dairy cattle

ROBERT C. LAMB and MELVIN J. ANDERSON

Increased milk production with greater feed efficiency is essential to the future economy of the dairy industry.

Forced into action by spiraling costs, successful dairymen are increasing the efficiency with which they utilize their land, labor and capital. But are they developing more efficient dairy cows? While it is true that levels of production are continually increasing, it is also true that dairy cows are consuming larger amounts of feed, particularly concentrates.

Some estimates of the efficiency of converting feed into milk have been made, but they provide very little information for use in breeding or selecting dairy cattle. Simply stated, we do not positively know if or how feed efficiency is inherited. If feed efficiency is genetically controlled we can speed our progress by selecting for it.

Scientists from the U.S. Department of Agriculture and the Utah Agricultural Experiment Station are currently conducting cooperative studies at the Dairy Experimental Farm at Logan on the inheritance of feed utilization efficiency in dairy cattle.

FORAGE vs. GRAIN

Although the dairy cow is one of the better animals for converting feed into materials for human consumption, she is still relatively inefficient. It has been estimated that dairy cows convert only from 13 to 44 percent of the digestible energy consumed into milk.

ROBERT C. LAMB and MELVIN J. ANDERSON are research scientists with the Dairy Cattle Research Branch of the Agricultural Research Service. They collaborate with the Department of Dairy Science.

In view of possible world-wide food shortages, this matter of feed efficiency is very important because grains can be used directly for human consumption. During food shortages, therefore, a cow may be in direct competition with man. Obviously in this situation the luxury of feeding grain to livestock is questionable. However, since forages cannot be utilized directly by man, livestock will still remain important in producing food for humans. In Utah, our cheapest sources of nutrients for livestock are forages. In fact, much of our land can produce little else. The problem then is not only to develop higher producing strains of dairy cattle, but to develop cows capable of more efficiently converting forage into milk.

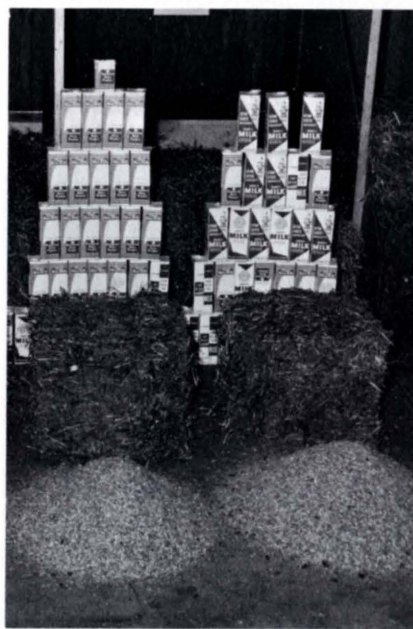


Figure 1. Differences in efficiency are illustrated by the daily feed consumption and milk production of two cows. Note the slightly larger pile of feed and fewer milk cartons for the cow represented on the right. Although the difference per cow per day may be small, it adds up to many dollars for an entire herd in 1 year.

WHAT IS FEED EFFICIENCY?

Before we can select dairy cows for feed utilization efficiency, we need to understand what it is and then determine whether it is an inherited characteristic. This article outlines answers to the first question. In later articles, results of studies aimed at answering the second question will be reported.

Basically, efficiency can be interpreted as some ratio of output to input. In terms of feed utilization efficiency this might be expressed as pounds of milk produced per pound of feed consumed. However, this is an over-simplification since nutrient content of milk, and especially fat content, can vary considerably. Since fat contributes about 50 percent of the energy in milk and since feeding practices also vary over a wide range, some standard measures for milk energy and feed intake are necessary.

The energy content of the milk can be put on a standard basis for all cows by converting production to a 4 percent fat-corrected-milk (FCM) basis. This is accomplished by using the formula:

$$4\% \text{ FCM} = .4 \times \text{milk} + 15.0 \times \text{fat}$$

This simply tells us how much milk containing 4 percent fat would have been produced based on a cow's actual production of milk and fat. We use 4 percent FCM rather than 3.5 percent or some other value because the average pound of 4 percent milk contains 340 calories. Thus, by using this transformation, milk production can be easily converted to energy output.

To convert feed consumption to an energy basis, the actual consumption of feed first must be measured

for each individual cow. Since different types of feeds and even different lots of the same type of feed vary considerably in their moisture content, feed consumption must be converted to a dry matter basis. For example, if a cow consumes 30 pounds of corn silage containing 25 percent dry matter, 20 pounds of alfalfa containing 88 percent dry matter and 10 pounds of concentrate containing 90 percent dry matter, then her total consumption for the day would be 60 pounds of feed but only 34.1 pounds of dry matter. The other 25.9 pounds would be water, which has no energy value.

Knowing the dry matter consumption is only a first step. Various feeds differ considerably in their digestibility and in their nutrient content. Fortunately, techniques are available by which the digestibility and energy values of the feeds can be evaluated, thereby permitting converting feed consumption to a digestible-energy basis.

A convenient formula to calculate efficiency of converting feed into milk is:

$$\text{Percent Gross Feed Efficiency} = \frac{\text{Calories energy produced}}{\text{Cal. digest. energy cons.}} \times 100.$$

GROSS vs. NET EFFICIENCY

The measurement of gross efficiency shown above is not necessarily the final answer. It does not take into consideration other energy losses, size of the cow, and whether she is gaining or losing weight. In

other words, it does not indicate how much of the energy consumed has been lost in the urine, heat, and gases, and how much has been used for growth, fattening, or body maintenance.

Figure 2 is a diagram of how feed intake may be utilized by the dairy cow. The animal body requires repair material to keep it in good running order and energy with which to do its work. Part of the energy consumed is lost in heat and waste products and part is used daily for body maintenance. The remainder is available for either milk production, reproduction, body growth, fattening or any combination of these functions.

To do any work, a cow first must meet her maintenance requirements. The amount needed for maintenance is related to body size, and it is fairly constant for any given size of cow.

The approximate amount of nutrients needed for reproduction and for a given change in body size (growth or fattening) also is known. Thus, when the size, weight change, and reproductive status of the cow is known, the nutrients required to support these functions can be subtracted from the digestible energy and the remainder used to calculate the efficiency of the cow. This is called net efficiency for milk production.

Since it requires more feed to maintain a larger cow, then for two cows with equal production the smaller cow will probably be the

most efficient. However, since larger cows generally produce more as well as eat more, the larger cows may be just as efficient. From an economic standpoint the larger cow may be more profitable.

Body weight losses can not be overlooked when comparing efficiencies between cows. Larger body weight losses may indicate a higher efficiency than actually occurs because body reserves are being converted to milk. Efficiency measured over a complete lactation may be more realistic than when it is measured for a brief period during peak production early in the lactation.

Which, then, is the most important, net efficiency or gross efficiency? Since we are trying to determine if efficiency is genetically controlled, perhaps some measure of net efficiency which measures how the cow utilizes her feed above maintenance requirements may be the answer we are seeking. However, from a practical standpoint the dairyman is most interested in gross efficiency since this is more directly a measure of what he gets back for what he puts in.

In the final analysis we need to know something about both the gross efficiency and the net efficiency of individual cows and about the relationship between the two, particularly from a genetic standpoint.

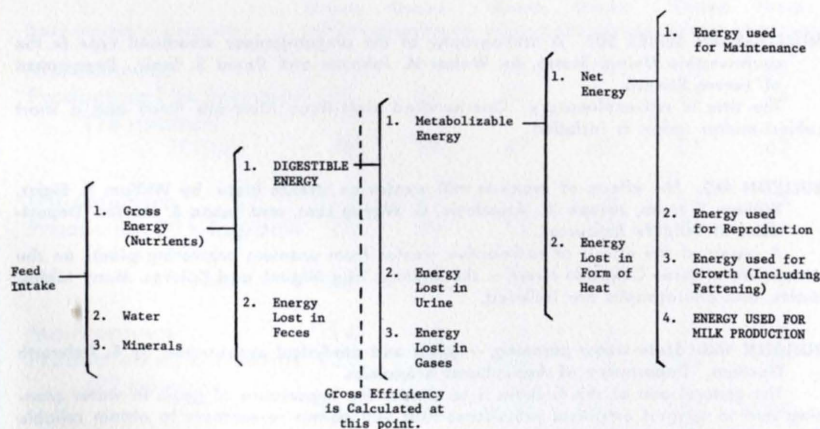


Figure 2. This diagram illustrates how food intake may be utilized by the dairy cow.



Harvesting Water With Catchments

When it comes to developing water supplies, man usually thinks in terms of drilling holes, damming rivers, desalting oceans, and even bombarding clouds. But aside from positioning a kettle under a leak in the ceiling, he seldom makes any effort to capture normal rainfall.

In recent years, recurring water shortages have forced many informed people to think seriously about our water sources. As a nation, we are beginning to realize that as our demands for water increase, the cost of obtaining water may also increase. We're getting used to the idea of paying for a commodity we once thought was free. When the costs of desalination, sewage reclamation, and other methods of expanding the water supply are compared, artificial catchments usually prove to be the most economical sources of water.

Countless billions of gallons fall every year, even on deserts; much of it evaporates right back into the atmosphere without having served any useful purpose. This unused water — clean, soft, and ours for the taking — may prove a valuable supplement to both farm and city water supplies as the demand for quality water edges upward.

Catching rainwater is simple. All one needs is a smooth, reasonably waterproof surface tilted toward a container that will hold the runoff. As early as 4,000 years ago, inhabitants of the Negev desert in Israel picked rocks from hillsides and smoothed the soil so that rainwater would flow down to low-lying fields. The practice made agriculture possible in a region averaging only 4 inches of rainfall per year.

In some parts of the world, notably on the island of Gibraltar, rainfall furnishes the primary water supply. Elsewhere, this water source has been neglected. Once-popular cisterns in rural America, for example, have given way to central water systems.

Cost has limited the development of water-harvesting techniques. A

1-inch rainfall produces nearly 6 gallons of water per square yard, or roughly 25,000 gallons per acre. The cost of water harvesting depends on the average annual rainfall in a given region, which determines how much land must be waterproofed to collect a given amount of water, which in turn determines how much money must be spent on waterproofing materials.

Traditionally, catch basins for

collecting rainfall on a large scale have been made from galvanized metal or concrete. Such catchments — used with varying success in Hawaii and other areas of tropical rainfall — cost from \$2 to \$3 per square yard.

Lloyd E. Myers, director of the USDA Water Conservation Laboratory in Phoenix, Arizona, has reduced this cost figure to 75¢ per square yard by waterproofing with

NEW PUBLICATIONS

BULLETIN 461. Development and use of foothill ranges in Utah, by C. Wayne Cook. Department of Range Science.

Dr. Cook gives the findings of studies carried out at two experimental range areas located near Eureka and Vernon, Utah. He describes the methods, results, and costs of developing and utilizing seeded foothill range for spring grazing.

UTAH RESOURCES SERIES 33. Sheep ranching in Utah's economy, 1964, by N. Keith Roberts and G. T. Blanch. Department of Agricultural Economics.

The authors give a brief historical sketch of sheep ranching in Utah, then show the economic condition of the industry in 1964.

UTAH RESOURCES SERIES 34. Dry-lot feeding of cattle in Utah, 1964-1965, by Ellis W. Lamborn. Department of Agricultural Economics.

Dr. Lamborn briefly reports the extent and characteristics of the cattle feeding industry in Utah and the place of this industry in the marketing channel for livestock.

UTAH RESOURCES SERIES 35. Processing costs in the frozen sour cherry industry, Utah County, 1964, by Ellis W. Lamborn and Richard K. Hart. Department of Agricultural Economics.

The authors describe the processing techniques of the three major sour cherry processing plants in Utah County. They give an analysis of data, show production costs and suggest several methods of more efficient operation.

MIMEOGRAPH SERIES 498. Continuous salt removal vs. periodic reclamation, by H. B. Peterson and Abdar-Wahhab Sallam. Department of Agricultural and Irrigation Engineering.

A semi-technical paper which furnishes 13 equations to describe the amount of water required to control soil salinity in arid and semi-arid regions.

MIMEOGRAPH SERIES 499. The role of carbohydrate reserves in managing range plants, by C. Wayne Cook. Department of Range Science.

This is a shortened version of UTAH RESOURCES SERIES 31 described in the September 1966 issue of *Utah Science*.

MIMEOGRAPH SERIES 501. A bibliography of the pinyon-juniper woodland type in the southwestern United States, by Walter H. Johnson and David R. Innis. Department of Forest Science.

The title is self-explanatory. One-hundred sixty-three titles are listed and a short subject-matter index is included.

BULLETIN 462. The effects of uranium mill wastes on stream biota, by William F. Sigler, William T. Helm, Joseph W. Angelovic, D. Wayne Linn, and Susan S. Martin. Department of Wildlife Resources.

A report of the effects of radioactive wastes from uranium processing plants on the stream life of three Colorado rivers — the Animas, San Miguel, and Dolores. Many tables, charts, and photographs are included.

BULLETIN 463. State water planning — goals and analytical approaches, by B. Delworth Gardner. Department of Agricultural Economics.

The general aim of this bulletin is to discuss the importance of goals in water planning and to suggest empirical procedures that will permit researchers to obtain reliable data needed for planning purposes.

liquid asphalt. The asphalt can be sprayed on hillsides with a boom sprayer at the rate of 1,250 feet per minute. During a 3-year study, virtually 100 percent of the rain that fell on the experimental pavements was harvested. Current research with materials indicates that annual catchment costs can be further reduced to 2¢ per yard.

C. W. Lauritzen, a soil scientist in the Agricultural Research Service at Logan, Utah, in collaboration with members of the Utah Agricultural Experiment Station, developed a butyl rubber rain trap that is now available commercially at cost of \$4,000 to \$5,000. The trap consists of a rubber sheet up to 100 x 100 feet square and a blimp-like rubber bag with a capacity of up to 50,000 gallons. A pipe runs from the bag to a stock tank, and a float valve regulates the flow of water from bag to tank. Plastic films and fiberglass also have been used to line catch basins.

Like Myers, Lauritzen is chiefly concerned with developing water supplies for livestock. In semi-arid regions of the country, much land would be suitable for grazing if drinking water were available.

McDANIEL MITE PROBLEM

(Continued from page 27)
that some of the chemicals commonly used in our orchards are deadly to the predatory mites, while others are only slightly harmful. One of the sprays which seems to be detrimental to predatory mites is the delayed dormant use of lime sulfur.

Karathane, for mildew control, is less harmful. The oil plus phosphate sprays apparently do less harm to the predatory mites than does lime sulfur. As time progresses we hope to learn which of our common miticides and insecticides best preserve the beneficial predators.

Table 1. Resistance to selected miticides which have been used in Utah apple orchards

Chemical	First experimental use in Utah	First commercial use in Utah (approx.)	Resistance First noted	Other fate
Parathion	1947	1948	1952	
Aramite	1950	1951	none	ruled out because of cancer danger
Systox	1952	1954	1958	
Kelthane	1956	1957	1960	
Trithion	1958	1958	1963	
Guthion	1958	1959	1958	
Tedion	1958	1960	1963	
Ethion	1958	1960	1962	
Morocide	1962	1964	none	

CLEAN WATER

(Continued from page 10)

Presumably what happens in the present Logan sewage system is as follows: (1) An initial breakdown of sewage materials in the sewer

ditch allows the growth of *Sphaerotilus*. (2) In the pond, a settling of the large sewage particles is followed by their digestion and a release of nutrients. These nutrients then are incorporated into the plant materials and small animals growing in the pond. (3) The plants and animals are carried along with the water. They eventually die and are digested, changing to elemental forms that are picked up by different species of plants and animals downstream. Ultimately, these are incorporated into the fish and biomass found in the Logan River.

A sewage lagoon system such as will go into effect for Logan in 1967 is expected to eliminate harmful organisms and provide an end product of pure water. The installation will provide an excellent out-door laboratory to study all of the ecological relationships of sewage organisms.

With adequate knowledge of these biological systems the sanitary engineer, can exercise a control which ultimately will result in pure water wherever lagoon-type sewage treatment systems are practical.

NOTE: In the September 1966 issue of Utah Science an article was printed entitled CALCIUM: PHOSPHORUS RATIOS FOR DAIRY COWS. The figures for cows producing 30 kilograms of milk in table 1 were incorrect. The corrected table is shown below.

Table 1. Example of calcium and phosphorus requirements

Body weight in kilograms	500 Kilograms (1100 pounds)		600 Kilograms (1320 pounds)		700 Kilograms (1540 pounds)	
	Grams calcium	Grams phosphorus	Grams calcium	Grams phosphorus	Grams calcium	Grams phosphorus
Maintenance	14	14	16	16	18	18
Production 15 kilograms (33 pounds)	33	24	33	24	33	24
TOTAL	47	38	49	40	51	42
Maintenance	14	14	16	16	18	18
Production 30 kilograms (66 pounds)	72	54	72	54	72	54
TOTAL	86	68	88	70	90	72
Maintenance	14	14	16	16	18	18
Production 45 kilograms (99 pounds)	122	90	122	90	122	90
TOTAL	136	104	138	106	140	108

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